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THE EFFECTS OF DEXTROAMPHETAMINE SULFATE ON MALE ATHLETES IN THE NONCOMPETITIVE SEASON

by

© NANCY L. WOOD

A THESIS

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ABSTRACT

The purpose of this study was to investigate the effects of dextroamphetamine sulfate on selected physiological, psychological, and physical performance parameters of male athletes in the non-competitive season. A sample of twelve volunteer male athletes ranging in age from 18 to 33 years participated in the study. Each subject received 0.14 mg. per kilogram of body weight of dextroamphetamine sulfate in a solution of eight ounces of orange juice.

Predicted work loads for all subjects were determined from the results of a preliminary testing session involving a progressively increased work load test on the bicycle ergometer. These work loads, corresponding to 90% of the subjects' maximum heart rates attained during the preliminary session, were used for the next three testing sessions.

For the three testing sessions, each subject completed the test protocol once without taking either dextroamphetamine sulfate or the placebo, once after being administered dextroamphetamine sulfate, and once after being administered the placebo. The order in which the subjects received the three treatments was determined by a Latin square design. Both the dextroamphetamine sulfate and the placebo were administered double blind one-half hour prior to exercise.

Resting measurements of heart rate, systolic and diastolic blood pressures, and oxygen uptake were taken one-half hour after reporting to the laboratory. Endurance performance time on the bicycle ergometer at the predetermined constant work loads was measured. Heart rate, systolic and diastolic blood pressures, oxygen uptake, and

ratings of perceived exertion were measured at specific time intervals during exercise. Recovery measurements of heart rate, systolic and diastolic blood pressures, and oxygen uptake were taken five, ten, and fifteen minutes following the end of exercise.

Dextroamphetamine sulfate in the dose of 0.14 mg. per kilogram of body weight had no significant effects on heart rate, systolic or diastolic blood pressures, or oxygen uptake measured at rest; systolic or diastolic blood pressures, oxygen uptake, or ratings of perceived exertion measured during exercise; or diastolic blood pressure measured during recovery from exercise. The drug administered had no significant effect on endurance performance time on the bicycle ergometer. Heart rate was the only parameter measured during exercise that was significantly affected by the administration of the drug. Significant drug effects were reported for both heart rate and systolic blood pressure measured during recovery from exercise. Oxygen uptake measured during recovery from exercise was significantly different between the drug and control treatments, but not between the drug and placebo treatments.

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CHAPTER I

STATEMENT OF THE PROBLEM

INTRODUCTION

With the emphasis on excellence and winning in competitive sport, and the advantages of prestige and success for the individuals involved, athletes are subjected to pressures to engage in artificial methods to improve their levels of physical performances. The importance of small but significant improvements in performances, that may be difficult to attain by normal methods, has led to the widespread use of ergogenic aids in athletics.

The use of substances to enhance physical performances has been known since ancient times (30, 43). The Greeks and Romans described the use of agents such as cannabis, opium, hyoscyamus, and stramonium leaves (43). Thus, pharmacological agents are ergogenic aids that were widely used in athletics in ancient times, and are still in wide use in athletics today.

Drugs play an important role in our culture. As athletics form a significant part of our culture, drugs play an integral role in athletics. Amphetamines are the drugs most commonly used to stimulate athletic performances (22, 30, 43, 52, 53). It is well known that amphetamines, as a central nervous system stimulant, have the ability to decrease or mask the physiological sense of fatigue (21, 30, 33, 44, 45, 47, 52, 53). Amphetamines, due to their ability to mask the perception of fatigue symptoms, cause further strain to be placed on the physiological processes that are already naturally strained by

physical exertion. Thus, the perception of fatigue may be masked due to the amphetamines, but the physiological fatigue is not abolished. It has been hypothesized that in events of prolonged duration, this masking of physiological fatigue may be dangerous to the athlete; and he may be strained beyond his natural physiological limitations. This assumption has not been documented with properly controlled research studies.

There is lack of unanimity in the literature on the effects of amphetamines on human physical performances. Smith and Beecher (66) concluded that amphetamine sulfate in the dose of 14 mg. per 70 kg. of body weight, taken orally two to three hours prior to swimming, running, weight-throwing, or shot-putting, improved the performances of 75% of the 57 male trained athletes studied. However, Karpovich (40) reported that amphetamine sulfate, in the oral doses of 10 or 20 mg. given one hour or thirty minutes respectively prior to being tested, had no effects on the physical performances of the 54 male athletes tested as measured by times in treadmill running, swimming, and track running. Haldi and Wynn (36) reported that five milligrams of benzedrine sulfate given orally to 12 subjects, one-half hour prior to being tested, had no effects on their swimming performances. Smith, Weitzner, and Beecher (67) concluded that amphetamine sulfate, in the dose of 14 mg. per 70 kg. of body weight, given orally two and one-half hours prior to swimming, improved the performances of the 15 subjects tested only when the subjects swam in groups. Borg et al. (16) reported improvements in the final performances of a series of intermittent and maximal work periods of short duration on the bicycle ergometer after 10 subjects had orally ingested 10 mg. of amphetamine sulfate, thirty minutes prior

to being tested, as compared to the performances of the 14 subjects who had been administered placebos. Golding and Barnard (31) reported that 15 mg. of d-amphetamine sulfate, given orally two to three hours prior to being tested, had no effects on all-out treadmill running times of 20 subjects. Margaria, Aghemo, and Rovelli (49) reported that 10 mg. of methedrine, given orally ninety minutes prior to being tested, had no effects on performance times of subjects running to maximum on the treadmill. Somerville (69) reported that doses of 15, 30, or 35 mg. of benzedrine given orally to 150 soldiers near the end of either 17 or 56 hours of physically fatiguing exercises had no effects on performance times on obstacle courses compared to the performance times of the 100 soldiers who had been administered placebos. Cuthbertson and Knox (20) reported that 15 mg. of methedrine given orally to 27 soldiers, immediately prior to being tested, had no effect on the total time taken to cover a 18 mile walk as compared to the 28 soldiers given placebos. Foltz, Schiffrin, and Ivy (27) reported that 10 mg. of amphetamine sulfate given orally to 23 male subjects, one hour prior to being tested, had no significant effect on the work output of the subjects tested during a bench stepping test.

There is also no unanimity in the literature on the effects of amphetamines on physiological parameters. Altschule and Iglauer (1) reported that oral doses of benzedrine greater than 10 mg. and intramuscular injection of 10 mg. of benzedrine, given immediately prior to being tested, produced increases in resting systolic and diastolic blood pressures but had no effect on heart rate at rest of the 15 subjects tested. Finkelstein, Alpern, and Gantt (25) concluded that amphetamine sulfate in oral doses of 10 to 15 mg. and 20 to 30 mg.,

given fifteen minutes prior to measurements being taken, increased systolic and diastolic blood pressures at rest, but had no effect on heart rate at rest of the 19 subjects tested as compared to the results of the 19 subjects given placebos and the 17 subjects acting as controls. Goldstein, Searle, and Schimke (32) reported that 10 mg. of d-amphetamine sulfate administered orally to 19 subjects, one hour prior to measurements being taken, had no effects on resting heart rate, or systolic or diastolic blood pressures. Snyder, Faillace, and Weingartner (68) concluded that neither 1.5 mg. of 2,5-dimethoxy-4-ethyl amphetamine (DOET) nor 10 mg. of dexedrine, administered orally to 10 male university students, had any effects on resting heart rate, or systolic and diastolic blood pressures for a period covering six hours after drug administration. Martin _et al_. (50) reported that subcutaneous administration of 7.5, 15, and 30 mg. per 70 kg. of body weight of d-amphetamine sulfate, and 15 and 30 mg. per 70 kg. of body weight of d-methamphetamine sulfate produced increases in heart rate and mean blood pressure of 12 subjects tested for twelve hours after drug administration. Segers, s'Jongers, and Lewillie (62) reported that three hours after administering orally 25 mg. of dexedrine to five subjects there was an increase in heart rate and oxygen consumption at rest and during exercise of a submaximal and maximal nature on the bicycle ergometer, in systolic blood pressure during exercise, and heart rate during recovery from exercise. The drug tested had no effects on systolic blood pressure during rest or recovery from exercise; diastolic blood pressure during rest, exercise, or recovery from exercise; and oxygen consumption during recovery from exercise. Margaria, Aghemo, and Rovelli (49) reported that 10 mg. of methedrine

orally administered, in capsule form, ninety minutes prior to maximal performances on the treadmill of three male subjects, had no effects on maximum oxygen consumption or maximum heart rate attained during exercise. Golding and Barnard (31) reported an increase in resting heart rate and systolic blood pressure, two to three hours after 20 subjects had been orally administered 15 mg. of d-amphetamine sulfate. The drug used also retarded systolic blood pressure recovery following the first run on the treadmill, and retarded heart rate and systolic blood pressure recovery following the second run on the treadmill. Seashore and Ivy (61) reported increases in heart rate, and systolic and diastolic blood pressures of 16 soldiers who had been given orally two doses of 10 mg. of benzedrine nine to ten and one-half hours and three to four hours prior to the measurements being taken. The soldiers had been engaged in all day marches and all night guard duty. Seashore and Ivy (61) reported no change in heart rate, and increases in systolic and diastolic blood pressures of 18 soldiers after oral administration of one or two doses of 10 mg. of benzedrine, nine and one-half hours and sometimes three to four hours prior to the measurements being taken. The soldiers had been engaged in 15 to 16 hours of continuous marching and guard duty.

The evidence accumulated from studies dealing with the effects of amphetamines on physical performance parameters and physiological parameters presents contradictory findings and have dealt almost exclusively with activities of short duration. The literature reviewed revealed little evidence on the effects of amphetamines on endurance activities of relatively prolonged duration. Thus, studies involving exercise periods of a longer duration so as to simulate athletic events

that are performed over a long period of time need to be conducted.

THE PROBLEM

The purpose of this study was to investigate the effects of dextroamphetamine sulfate on selected physiological, psychological, and physical performance parameters of male athletes in the non-competitive season. More specifically, the parameters investigated were as follows:

1) Physiological Parameters - heart rate, systolic blood pressure, diastolic blood pressure, and oxygen uptake at rest, during exercise on the bicycle ergometer, and during recovery from exercise;
2) Psychological Parameter - subjective ratings by the subjects of their perception of exertion during exercise on the bicycle ergometer;
3) Physical Performance Parameter - endurance performance on the bicycle ergometer.

HYPOTHESES

For the purpose of investigating the parameters as outlined in the problem, the following hypotheses were tested at the 0.05 level of significance:

1) No significant change occurs in heart rate at rest one-half hour after orally ingesting 0.14 mg. per kilogram of body weight of dextroamphetamine sulfate.
2) No significant change occurs in systolic blood pressure at rest one-half hour after orally ingesting 0.14 mg. per kilogram of body weight of dextroamphetamine sulfate.

3) No significant change occurs in diastolic blood pressure at rest one-half hour after orally ingesting 0.14 mg. per kilogram of body weight of dextroamphetamine sulfate.

4) No significant change occurs in oxygen uptake at rest one-half hour after orally ingesting 0.14 mg. per kilogram of body weight of dextroamphetamine sulfate.

5) No significant change occurs in heart rate during exercise as a result of orally ingesting 0.14 mg. per kilogram of body weight of dextroamphetamine sulfate.

6) No significant change occurs in systolic blood pressure during exercise as a result of orally ingesting 0.14 mg. per kilogram of body weight of dextroamphetamine sulfate.

7) No significant change occurs in diastolic blood pressure during exercise as a result of orally ingesting 0.14 mg. per kilogram of body weight of dextroamphetamine sulfate.

8) No significant change occurs in oxygen uptake during exercise as a result of orally ingesting 0.14 mg. per kilogram of body weight of dextroamphetamine sulfate.

9) No significant change occurs in heart rate during recovery from exercise as a result of orally ingesting 0.14 mg. per kilogram of body weight of dextroamphetamine sulfate.

10) No significant change occurs in systolic blood pressure during recovery from exercise as a result of orally ingesting 0.14 mg. per kilogram of body weight of dextroamphetamine sulfate.

11) No significant change occurs in diastolic blood pressure during recovery from exercise as a result of orally ingesting 0.14 mg. per kilogram of body weight of dextroamphetamine sulfate.

12) No significant change occurs in oxygen uptake during recovery from exercise as a result of orally ingesting 0.14 mg. per kilogram of body weight of dextroamphetamine sulfate.
13) No significant change occurs in endurance performance on the bicycle ergometer as a result of orally ingesting 0.14 mg. per kilogram of body weight of dextroamphetamine sulfate.
14) No significant change occurs in subjective ratings of perceived exertion during exercise as a result of orally ingesting 0.14 mg. per kilogram of body weight of dextroamphetamine sulfate.

JUSTIFICATION FOR THE STUDY

As is evident from the research reviewed in the introduction, no definite effects of amphetamines on physical performance parameters and physiological parameters can be stated. To the investigator's knowledge, no study has yet investigated the effects of amphetamines on one's subjective ratings of perceived exertion.

As stated in the introduction, dextroamphetamine sulfate has the ability to mask the perception of the natural physiological state of fatigue (21, 30, 33, 44, 45, 47, 52, 53). The significance of this statement may lie in physiological, psychological, and / or physical performance considerations - thus the inclusion of specific parameters from all three realms.

An individual may be able to maintain endurance performance for a longer period of time even if he is physiologically fatigued - thus, the measuring of endurance time. Measurement of the physiological parameters - namely, heart rate, blood pressure, and oxygen uptake were chosen as these three parameters are felt to be of importance in

endurance performance. "There is obviously a fundamental relationship between a physiological indicator of physical stress such as heart rate and a psychological indicator such as rating of perceived exertion" (11:92). "Perceived exertion and work intensity on the bicycle ergometer are correlated in a linear fashion" (51:97). Although, under normal conditions, the actual physical exertion and an individual's perception of the exertion are highly correlated; under the influence of dextroamphetamine sulfate the individual's perception of the exertion may be masked or distorted which may affect physical performance and physiological parameters. Thus, the inclusion of the rating scale of perceived exertion to investigate the effects of dextroamphetamine sulfate on one's subjective ratings of perceived exertion.

It is clear from the literature reviewed that the studies have dealt primarily with athletic and physical performances of short duration. However, the masking of the sense of fatigue is the prime attribute of amphetamines, and therefore, the importance of the pharmaceutical action of amphetamines lies in activities of prolonged duration. Amphetamines, by masking factors that may limit performance (for example, fatigue and boredom) in activities of prolonged duration, may help the athlete to attain his optimum performance level. That is, because of many influencing factors, athletes may only be performing up to their subjective limits, but amphetamines may increase their performances to their optimum levels. Also, as the physiological requirements vary from one activity to another, (for example, running 100 yards and running 26 miles) it is not possible to generalize from an activity of short duration to an activity of prolonged duration.

From the literature reviewed, it is evident that very few studies have dealt with dextroamphetamine sulfate. However, this particular amphetamine is preferred by athletes as it is twice as potent as amphetamine sulfate in central nervous system action (33).

Achieving individual maximum performance is a combination of physical, psychological, and physiological parameters. This study was an attempt to interrelate selected physiological, psychological, and physical performance parameters that may be of importance to obtaining maximum success in athletic performances.

Therefore, the need definitely exists for research to examine the effects of dextroamphetamine sulfate on selected physiological, psychological, and physical performance parameters in exercise of a relatively long duration, under properly controlled experimental conditions and under qualified medical supervision.

LIMITATION OF THE STUDY

1) The study was limited by the extent to which the subjects through their own volition exercised to fatigue. It was impossible to have absolute control over the subjects' motivational levels during the testing sessions.

DELIMITATIONS OF THE STUDY

1) The study was limited to twelve volunteer male athletes.
2) The study was limited by the administration of the drug orally in a solution of eight ounces of orange juice.
3) The study was limited by the importance of considering individual variation. Therefore, each subject was used as his own control.

4) The study was limited by the investigator's definition of endurance performance.
5) The study was limited by the physiological, psychological, and physical performance parameters as stated in the problem.

DEFINITION OF TERMS

1) Dextroamphetamine Sulfate - a sympathomimetic drug acting as a central nervous system stimulant; and is the d-isomer of amphetamine, and is manufactured under the trade name of dexedrine.
2) Double Blind - means that a placebo is being used and neither the subject nor the experimenter knows whether the subject being tested was administered the placebo or the drug during any of the testing sessions. This is a necessary condition in human drug research if the results are to be attributed to the effects of the drug as a pharmacological agent.
3) Endurance Performance - "The ability to maintain a high rate of physical work output for a relatively long period of time without decrement" (41:33). Specifically, for the purpose of this study, endurance performance will be measured by the length of time that a subject can maintain a predetermined constant work load at a constant pace of 60 revolutions per minute on the bicycle ergometer.
4) Kilopond (kp.) - "1 kilopond is the force acting on a mass of 1 kilogram at normal acceleration of gravity" (3:13).
5) Kilopond Meters (kpm.) - unit to express the rate of work on the bicycle ergometer determined by the braking power (kp.) that is set by adjustment of the belt tension multiplied by the distance pedalled (m.).

6) Kilopond Meters/Minute (kpm./min.) - the rate of work in kpm. expressed per minute.
7) Placebo - a substance composed of pharmacologically inactive ingredients used as a control in human drug research. It is used in the same form as the drug being tested in the research. Thus, it must possess the same physical characteristics as the drug being tested.
8) Perceived Exertion - "one's subjective rating of the intensity of work being performed" (51:97).
9) Sympathomimetic Drug - drug that produces effects similar to those of impulses that are transmitted by the postganglionic fibres of the sympathetic nervous system (9).

CHAPTER II

REVIEW OF THE LITERATURE

INTRODUCTION

The present study was conducted for the purpose of investigating the effects of dextroamphetamine sulfate on selected physiological, psychological, and physical performance parameters of male athletes in the noncompetitive season. More specifically, the parameters investigated were as follows:

1) Physiological Parameters - heart rate, systolic blood pressure, diastolic blood pressure, and oxygen uptake at rest, during exercise on the bicycle ergometer, and during recovery from exercise;
2) Psychological Parameter - subjective ratings by the subjects of their perception of exertion during exercise on the bicycle ergometer;
3) Physical Performance Parameter - endurance performance on the bicycle ergometer.

With attention to the aforementioned, the literature reviewed will encompass specifically the following:

1) The Effects of Amphetamines on Human Physical Performances - This includes actual physical performances, for example, swimming or running, or physical performances that have been simulated in the laboratory through testing on the bicycle ergometer or the treadmill.
2) The Effects of Amphetamines on Physiological Parameters - This includes heart rate, systolic blood pressure, diastolic blood pressure, and oxygen uptake in humans at rest, during physical performances, and during recovery from physical performances.

3) Ratings of Perceived Exertion During Physical Performances - This includes the subjective ratings by the subjects of their perception of exertion during exercise on the bicycle ergometer or the treadmill using the rating scale of perceived exertion developed by G. A. V. Borg (11).

THE EFFECTS OF AMPHETAMINES ON HUMAN PHYSICAL PERFORMANCES

The most extensive investigation that has been conducted in this area was reported by Smith and Beecher (66). The effects of amphetamine sulfate on the athletic performances of 57 male trained athletes were studied. Six separate experiments comprised 800 measured performances of the athletes - 18 swimmers, 26 runners, and 13 weight-throwers and shot-putters. All subjects received orally, in capsule form, on several separate occasions, either 14 mg. of amphetamine sulfate per 70 kg. of body weight, or a placebo, two or three hours prior to performing their event. All capsules were administered double blind. The percent of athletes whose performances significantly improved under the influence of amphetamine sulfate was as follows: swimmers - 69% ($p< 0.05$), runners - 73% ($p< 0.02$), and weight-throwers and shot-putters - 85% ($p< 0.01$). The amount of improvement from amphetamine sulfate by the three groups of athletes was: swimmers - 0.59 to 1.16%, runners - 1.5%, and weight-throwers and shot-putters - 3 to 4%. Amphetamine sulfate in the dose of 14 mg. per 70 kg. of body weight, taken two or three hours prior to swimming, running, and weight-throwing and shot-putting, significantly improved the performances of 75% of the highly trained athletes studied ($p< 0.0002$).

Karpovich (40) studied the effects of amphetamine sulfate, given orally, in capsule form, in doses of 10 mg. one hour prior to being tested, or 20 mg. thirty minutes prior to being tested, on the physical performances of 54 male college athletes. A total of 532 performances of 18 swimmers, 11 track men, and 25 treadmill runners were measured by running and swimming events as well as running to exhaustion on the treadmill. Amphetamine sulfate, in doses of 10 or 20 mg. given one hour or thirty minutes respectively prior to being tested, had no significant effects on physical performances as measured by times in treadmill running to exhaustion, swimming, and track running. A total of 50 subjects showed no changes in performances after ingesting amphetamine sulfate as compared to placebo results. Improvements in swimming were noted in three subjects, and one treadmill runner showed a decrement in performance after being administered amphetamine sulfate as compared to the placebo.

Haldi and Wynn (36), using 12 male subjects, studied the effects of five milligrams of benzedrine sulfate, given ninety minutes prior to being tested, on swimming performances. The drug was administered orally in capsule form. Benzedrine sulfate had no effects on the swimming times of the subjects studied. Smith, Weitzner, and Beecher (67) studied the effects of amphetamine sulfate on the swimming performances of 15 non-expert swimmers. Amphetamine sulfate in the dose of 14 mg. per 70 kg. of body weight was given orally two and one-half hours prior to swimming. Subjects swam twice on each day either alone or in groups of three. The only significant improvement after taking amphetamine sulfate occurred during the first trials when the subjects swam in groups ($p < 0.05$).

Knoefel (42) studied the effects of 10 or 20 mg. of amphetamine sulfate and methamphetamine on seven subjects on work output on the bicycle ergometer. The drugs were given two hours prior to being tested. Progressively increased work loads were used until the subjects reached a self-imposed maximum. Work output on the bicycle ergometer was increased after the subjects tested ingested 10 mg. of methamphetamine. In a study reported by Cuthbertson and Knox (20), six male military subjects cycled on the bicycle ergometer at a constant work load until exhaustion. Either 10 mg. of methedrine or 15 mg. of benzedrine was given when deterioration in performance was imminent or evident. Oral administration of the drugs increased the work outputs of the subjects on the bicycle ergometer. If deterioration had set in, work output rose within one-half to one and one-half hours after administration of the drugs and was maintained for about one hour. With placebo tablets, the work output gradually decreased. Hueting and Poulus (38) reported on the effects of 10, 20, or 30 mg. of methyl-amphetamine on exhaustive bicycle ergometer performances of six trained male subjects. Intramuscular injections of the drug were given double blind, one-half hour prior to being tested. Progressively increased work loads of 10 watts per minute were used for the exhaustive ride on the bicycle ergometer. There were no significant differences on bicycle ergometer performances after subjects were administered either placebo or methyl-amphetamine.

In a study reported by Foltz, Ivy, and Barborka (26), 10 to 15 mg. of amphetamine sulfate were administered intravenously to four subjects, thirty seconds to thirty minutes prior to performing rapidly exhausting work on the bicycle ergometer. The subjects used were previously trained on the bicycle ergometer from three to sixteen

months. A dose of 10 to 15 mg. of amphetamine sulfate injected intravenously did not increase the work output of the subjects tested. Borg et al. (16) studied the effects of oral administration of 10 mg. of amphetamine sulfate, thirty minutes prior to physical performances of 10 male subjects on the bicycle ergometer. The test consisted of a series of 10 working periods of maximal performances on the bicycle ergometer. Each working period lasted approximately forty-five seconds with fifteen seconds rest in between each working period. Amphetamine sulfate improved the final performances of the 10 subjects in the test used but not the initial ones compared to the performances of the 14 subjects who had been administered placebos.

Using only two competitive track cyclists, Wyndham et al. (74) studied the effects of oral administration of 10 mg. of methamphetamine solution on submaximal and maximal performances on the bicycle ergometer. Longer cycling times at maximal effort were reported after taking methamphetamine as compared to placebo. Cycling at 90% of his maximum oxygen consumption to exhaustion, one subject increased his cycling time 61% after taking methamphetamine as compared to placebo; and one subject increased his cycling time by 29% after taking methamphetamine as compared to placebo cycling at 90% of his maximum oxygen consumption to exhaustion. However, as only two subjects were used, this study can hardly be considered as anything more than two case studies; and the results have to be interpreted, if at all, with caution. In a study reported by Barták and Škranc (6) eight male subjects cycled at three submaximal work loads for six minutes each, and at maximal work loads for at least two minutes until exhaustion, one hour after orally ingesting 0.02 g. of benzedrine. The dose of

benzedrine given had no effects on the physical performances of the subjects tested.

Golding and Barnard (31) investigated the effects of 15 mg. of d-amphetamine sulfate on all-out treadmill running times of 10 unconditioned male university students and 10 conditioned male track athletes. The drug used was administered orally in capsule form two to three hours prior to being tested. The treadmill was set at 10 miles per hour at a grade of 8.5%. D-amphetamine sulfate, in the dose used, had no significant effects on all-out treadmill running times of the subjects tested. Margaria, Aghemo, and Rovelli (49), using three male subjects, studied the effects of 10 mg. of methedrine on performance times on the treadmill at a speed of 12 and 13 km./hr. with an incline of five percent until exhaustion. Each subject was tested five times with the drug. The drug was given orally in capsule form ninety minutes prior to being tested. Methedrine had no significant effects on the performance times of the subjects tested.

In a study reported by Somerville (69), five groups of 50 soldiers each were tested on performance times on obstacle courses after taking part in physically fatiguing exercises of 17 or 56 hours duration. A dose of 15 mg. of benzedrine, given to 50 soldiers, one hour prior to the end of the 17 hours of physically fatiguing exercises, did not improve the performance times on a 227 yards long obstacle course with six obstacles compared with the 50 soldiers given placebos. Doses of 30 or 35 mg. of benzedrine given in divided doses over twenty-four hours to two groups of 50 soldiers each, taking part in physically fatiguing exercises lasting 56 hours, produced no significant differences in performance times on a 500 yards long obstacle course

with nine obstacles as compared to the 50 soldiers who had been given placebos. Cuthbertson and Knox (20) reported a study using 55 military men that were kept without sleep for twenty-four hours; and then they had to walk 18 miles in three groups. Half of the subjects were given 15 mg. of methedrine and half of the subjects were given placebos immediately prior to beginning the walk. Methedrine had no effect on the total time taken to cover the 18 mile course as compared to placebo.

Foltz, Schiffrin, and Ivy (27) studied the effects of 10 mg. of amphetamine sulfate on 23 male untrained subjects on work output during a bench stepping test. The drug was given orally one hour prior to being tested. Each subject had a knapsack on his back loaded with a weight equal to one-third of his own weight. Amphetamine sulfate had no significant effect on the work output of the subjects tested.

THE EFFECTS OF AMPHETAMINES ON PHYSIOLOGICAL PARAMETERS

Altschule and Iglauer (1) studied the effects of oral doses of 10 or 30 mg. of benzedrine and intramuscular injection of 10 mg. of benzedrine on resting heart rate, systolic blood pressure, and diastolic blood pressure of 15 male and female subjects. Measurements were done in five minute intervals immediately after the administration of the drugs with the subjects in a semi-recumbent position. An oral dose of 10 mg. of benzedrine had no effects on systolic blood pressure or diastolic blood pressure. However, 10 mg. given intramuscularly and oral doses greater than 10 mg. caused definite increases in systolic and diastolic blood pressures. In all cases, systolic blood pressure increased more than diastolic blood pressure. Oral and intramuscular

doses of benzedrine produced no changes in the heart rates of nine subjects, increases in heart rates from four to eighteen beats per minute in four subjects, a decrease of eight beats per minute in one subject, and a decrease of five beats per minute in one subject. Where changes occurred in heart rates, no relationship existed between the dose of the drug given and the resulting change in heart rate.

Graybiel et al. (35) studied the effects of intramuscular administration of 20 mg. of benzedrine on eight male subjects on heart rate, systolic blood pressure, and diastolic blood pressure. Heart rates and blood pressure measurements were taken during three preliminary periods of eight minutes each prior to drug administration, and five succeeding periods of eight minutes each after being administered the drug. Heart rate was slightly higher after benzedrine as compared to placebo results. Systolic blood pressure was increased, and the increased level was sustained; while diastolic blood pressure increased only slightly after administration of the drug as compared to placebo.

Finkelstein, Alpern, and Gantt (25) studied the effects of oral administration of 10 to 15 mg. and 20 to 30 mg. of amphetamine sulfate on resting heart rate, systolic blood pressure, and diastolic blood pressure of 19 male and female students. The drug was administered fifteen minutes prior to the measurements being taken. Amphetamine sulfate in the oral doses of 10 to 15 mg. and 20 to 30 mg. significantly increased both diastolic and systolic blood pressures ($p < 0.05$) of the subjects tested, but had no effect on heart rate as compared to the results of the 19 subjects given placebos and the 17 subjects acting as controls. Systolic blood pressure increased eight millimeters and

and sixteen millimeters respectively for the two doses, 10 to 15 mg. and 20 to 30 mg.; while diastolic blood pressure increased six millimeters and twelve millimeters respectively for the two doses of 10 to 15 mg. and 20 to 30 mg.. Goldstein, Searle, and Schimke (32) reported that 10 mg. of d-amphetamine sulfate administered orally to 19 subjects one hour prior to measurements being taken had no significant effects on resting heart rate, or systolic or diastolic blood pressures of the 19 subjects tested compared to the results of the 19 subjects given placebos.

Snyder, Faillace, and Weingartner (68) studied the effects of oral administration of 1.5 mg. of 2,5-dimethoxy-4-ethyl amphetamine (DOET) and 10 mg. of dexedrine on 10 male university students. Heart rate and systolic and diastolic blood pressures were measured up to six hours after receiving the drugs. Neither DOET nor dexedrine had any significant effects on any of the parameters measured. Martin _et al_. (50) studied the effects of subcutaneous administration of 7.5, 15, and 30 mg. per 70 kg. of body weight of d-amphetamine sulfate, and 15 and 30 mg. per 70 kg. of body weight of d-methamphetamine sulfate, on resting heart rate and mean blood pressure of 12 male subjects. Measurements were taken one-half hour, one hour, two hours, three hours, four hours, five hours, and twelve hours after drug administration. All doses of both drugs produced a dose related increase in mean blood pressure. All doses of both drugs produced tachycardia. However, for the two drugs tested, there was an over-all negative correlation between heart rate and mean blood pressure ($p < 0.01$). The 7.5 and 15 mg. per 70 kg. of body weight doses caused a moderate increase in mean blood pressure, and a tachycardia during the

first five hours after drug administration. In contrast, the 30 mg. per 70 kg. of body weight dose caused a greater increase in mean blood pressure, and when the mean blood pressure was maximally elevated, the mean heart rate was not significantly different from the placebo value. However, five hours after administration of the 30 mg. per 70 kg. of body weight dose, mean blood pressure was decreasing, and a marked tachycardia was reported.

Segers, s'Jongers, and Lewillie (62) reported that three hours after administering 25 mg. of dexedrine to five male subjects, there was an increase in heart rate at rest and during exercise at 600 kpm./min. for thirty minutes followed by exercise at 1200 kpm./min. for five minutes. Oxygen consumption at rest and during exercise at 600 kpm./min. increased after ingesting the dexedrine, but the drug had no effect on oxygen consumption during recovery from exercise. Systolic blood pressure also increased during exercise following administration of the drug. Dexedrine produced no changes on systolic blood pressure at rest and during recovery from exercise; or diastolic blood pressure at rest, during exercise, or during recovery from exercise. After ingesting dexedrine, heart rate was increased 40% compared to resting values after five minutes of recovery from exercise. After ingesting placebo, heart rate after five minutes of recovery was accelerated only 17% compared to resting values. All subjects were tested at least twice after being administered dexedrine.

Higher heart rates during exhaustive bicycle ergometer performances, and during recovery from exercise of six trained male subjects following intramuscular injections of 10, 20, or 30 mg. of methyl-amphetamine, thirty minutes prior to being tested were reported

by Hueting and Poulus (38). Progressively increased work loads of 10 watts per minute were used for the exhaustive ride on the bicycle ergometer. Barták and Škranc (6) reported no differences in heart rate or oxygen consumption at rest or during submaximal or maximal exercise on the bicycle ergometer of eight male subjects after orally ingesting 0.02 g. of benzedrine one hour prior to being tested as compared to control and placebo results. However, heart rate at the second minute of recovery was significantly greater ($p < 0.05$) after being administered benzedrine as compared to control and placebo results. Oxygen consumption during the third and fifth minutes of recovery was significantly greater ($p < 0.05$) after being administered benzedrine as compared to control and placebo results.

Wyndham et al. (74) reported that 10 mg. of methamphetamine solution orally administered immediately prior to being tested had no effects on submaximal or maximal oxygen consumption or heart rate of two competitive track cyclists on performances on the bicycle ergometer. Margaria, Aghemo, and Rovelli cited a study by Lehmann, Straub, and Szakall (48) that concluded that amphetamine sulfate had no effects on oxygen consumption or heart rate of three subjects exercised to exhaustion on the cycloergometer.

Margaria, Aghemo, and Rovelli (49) reported that 10 mg. of methedrine orally administered, in capsule form, ninety minutes prior to maximal performances on the treadmill of three male subjects, had no significant effects on maximum oxygen consumption or maximal heart rate attained during exercise. Each subject was tested five times with the drug and five times with the placebo.

Pirnay et al. (56) reported no significant effects of 25 mg. of

dexedrine on oxygen consumption and heart rate during steady state exercise and exhaustive exercise on the treadmill of six trained male athletes. The drug was administered orally in capsule form, one-half and three hours prior to being tested. The test consisted of walking on the treadmill at a 10% incline at a work load for seven minutes duration with the speed progressively increased by one km./hr. every seven minutes until maximal steady state was attained; followed by a run at a work load for two minutes duration progressively increased in speed by two km./hr. every two minutes until exhaustion.

Golding and Barnard (31) reported a significant increase in resting heart rate ($p < 0.01$) and systolic blood pressure ($p < 0.001$) of 10 conditioned track athletes, two to three hours after oral administration of 15 mg. of d-amphetamine sulfate. The drug significantly retarded systolic blood pressure recovery ($p < 0.01$) following the first all-out treadmill runs by the 10 athletes tested, but had no effect on recovery heart rate. During recovery from the second all-out run (done 12 minutes after completing the first run) heart rate and systolic blood pressure recovery rates were significantly retarded ($p < 0.01$ and $p < 0.05$ respectively).

In a study reported by Cuthbertson and Knox (20) three subjects climbed five times up and down two steps each 10 inches high while stepping in time to a metronome beating 96 beats per minute. The test was done in intervals of one-half hour and after the first three tests, the subjects received orally 10 mg. of methedrine. The drug used had no significant effect on heart rate response to the test used. Cuthbertson and Knox (20) reported that the gradual fall in resting heart rate of eight male military subjects was arrested 45 minutes after oral

administration of 10 mg. of methedrine. A more sustained rise in resting heart rate was reported after 20 mg. of methedrine. A dose of 10 mg. of methedrine caused a rise of 10 to 20 millimeters in systolic blood pressure, and diastolic blood pressure varied similarly. A dose of 20 mg. of methedrine caused a definite rise in systolic blood pressure of six subjects, a slight rise in one subject, and a fall of 20 millimeters in one subject. Diastolic blood pressure fluctuated in parallel with systolic blood pressure.

Seashore and Ivy (61) reported a significant increase in heart rate, systolic blood pressure, and diastolic blood pressure ($0.01 < p < 0.05$) of 16 soldiers after being given orally two doses of benzedrine. The subjects received 10 mg. of benzedrine nine to ten and one-half hours and three to four hours prior to the measurements being taken. The soldiers had been engaged in prolonged physical activity - all day marches and all night guard. Seashore and Ivy (61) reported no change in heart rate and systolic and diastolic blood pressures were significantly increased in 18 soldiers ($p < 0.01$ and $p < 0.05$ respectively) after orally being administered, in capsule form, one or two doses of benzedrine. All subjects received 10 mg. of benzedrine nine and one-half hours prior to the physiological measurements being taken, and some subjects received another 10 mg. of benzedrine four to five hours prior to the measurements being taken. The soldiers had been engaged in prolonged physical activity of 15 to 16 hours duration of marching and guard duty or continuous marching.

SUMMARY OF THE EFFECTS OF AMPHETAMINES ON HUMAN PHYSICAL PERFORMANCES AND ON PHYSIOLOGICAL PARAMETERS

Contrast and inconsistency of results are evident from the studies reported in the preceding two sections of the review of the literature. The results are influenced by the number of subjects used, the type of subject used, the type of amphetamine used, the doses of the amphetamines used, the method of administration of the amphetamines, the time allowed for absorption of the amphetamines prior to measuring the parameters tested, and the actual physical performances and physiological parameters tested. With consideration given to these factors, little validity exists in comparing the studies presented. However, a few comments will be reported on the studies reviewed.

Of the sixteen studies reported in the section on Amphetamines and Human Physical Performances, six of the studies (6, 20, 26, 38, 42, 74) used less than 10 subjects. Interpreting any results from these studies using that few a number of subjects has to be done with caution. Of the other ten studies reported, seven studies (20, 27, 31, 36, 40, 49, 69) reported no changes in the physical performances measured after being administered the doses of the amphetamines used as compared to the placebos used. The other three studies (16, 66, 67) reported improvements in the physical performances measured with the doses of the amphetamines used as compared to the placebos administered.

Of the eighteen studies reported in the section on Amphetamines and Physiological Parameters, eight of the studies (6, 20, 20, 35, 38, 48, 56, 74) used less than 10 subjects. Interpreting any results from these studies using that few a number of subjects has to be done with

attention to the number of subjects tested. Of the other ten studies, (1, 25, 31, 32, 49, 50, 61, 61, 62, 68) the results for the parameters tested are as reported in the next few paragraphs.

For resting heart rate, four studies (1, 25, 32, 68) reported no change with the drugs used as compared to the placebos used; and three studies (31, 50, 62) reported an increase in heart rate as a result of the drugs used. The amphetamines administered produced an increase in systolic blood pressure at rest as reported by three studies (1, 25, 31) and had no effect on systolic blood pressure at rest as reported by three studies (32, 62, 68). Amphetamines had no effect on disatolic blood pressure at rest as reported by three studies (32, 62, 68) and produced an increase in diastolic blood pressure at rest as reported by two studies (1, 25). Mean blood pressure was increased after administration of the amphetamine used as reported in one study (50). One study (62) reported an increase in oxygen consumption at rest after administration of the amphetamine used.

Two studies (61, 62) reported increased heart rate during exercise following drug administration, and two studies (49, 61) reported no change in heart rate. An increase in systolic blood pressure during exercise was reported by three studies (61, 61, 62) following administration of the amphetamines used. An increase in diastolic blood pressure during exercise was reported by two studies (61, 61) following drug administration, and one study (62) reported no change in diastolic blood pressure during exercise following drug administration as compared to the placebo. For oxygen consumption during exercise, one study (49) reported no change with the amphetamine used as compared to the placebo result, and one study (62) reported an

increase in oxygen consumption during exercise following administration of the drug tested.

Heart rate during recovery from exercise was retarded with the amphetamines used as reported by two studies (31, 62) and one study (31) reported no change in recovery heart rate following drug administration. Systolic blood pressure during recovery from exercise was retarded following administration of the amphetamine used as reported by one study, (31) while one study (62) reported no change in systolic blood pressure during recovery from exercise following administration of the amphetamine used. One study (62) reported no change in diastolic blood pressure during recovery from exercise following drug administration; and one study (62) reported no change in oxygen consumption during recovery from exercise following administration of the amphetamine used as compared to the placebo result.

RATINGS OF PERCEIVED EXERTION DURING PHYSICAL PERFORMANCES

In the final analysis, human physical performance is dependent upon physical, physiological, and psychological determinants. Psychological determinants play an important role in the final outcome of performance. An individual's perception of his performance influences his reactions that determine the end result of his performance. Thus, an individual's performance depends on how he perceives what he is doing and not necessarily what he is actually doing. It then becomes essential to determine the relationship between the subjective and objective determinants of physical performance. G. A. V. Borg originated the concept of perceived exertion to study the psychological effort

involved in physical performance. The Borg Scale for Ratings of Perceived Exertion (11) is an attempt to quantify man's subjective perception of his physical performance in a psychophysical context.

Borg (11) reported a correlation coefficient of 0.62 between heart rates and ratings of perceived exertion of 69 male military conscripts from work on the bicycle ergometer at a constant work load of 1400 kpm./min.. Ratings of perceived exertion and heart rates were obtained every two minutes until a self-imposed maximum was reached. Borg (11) also reported a correlation coefficient of 0.72 between heart rates and ratings of perceived exertion of 43 male military conscripts using a progressive work test on the bicycle ergometer. The work load was started at 600 kpm./min. and was increased by 300 kpm./min. every sixth minute until exhaustion. Ratings of perceived exertion and heart rates were obtained every six minutes until exhaustion. Borg (10) reported a correlation coefficient of 0.85 between heart rates and ratings of perceived exertion of 73 male subjects who performed a physical work test on the bicycle ergometer. The work load was started at 300 kpm./min. and was increased by 300 kpm./min. every six minutes until a self-imposed maximum was reached. Heart rates and ratings of perceived exertion were recorded at the sixth minute of each work load. The scale used for the ratings of perceived exertion was the original 21-point scale that was developed by Borg.

Using 16 male university students, Skinner et al. (65) tested the validity and reliability of Borg's Scale for Ratings of Perceived Exertion. Subjects were tested with a progressively increased work load test and a test using a random order of various work loads on the bicycle ergometer. The progressive test began at 150 kpm./min. and was

increased every two minutes by 150 kpm./min. until a self-imposed maximum was reached. With the random test, every subject exercised for two minutes at 150 kpm./min. and then the work load was increased to either 300, 450, 600, 750, or 900 kpm./min. for four minutes. After a rest of eight minutes, the same procedure was followed until all five work loads were done. With both tests, heart rates and ratings of perceived exertion were recorded twenty seconds prior to completing each work load. Reliability was determined by testing each subject twice with each protocol. There were no significant differences in heart rates and ratings of perceived exertion between the random work load and the progressive work load bicycle ergometer tests. Correlation coefficients of 0.90 for heart rates and 0.79 for ratings of perceived exertion were reported between the progressive and random tests. Reliability coefficients of 0.87 and 0.91 for heart rates for the progressive and random tests respectively, and 0.80 and 0.78 for ratings of perceived exertion for the progressive and random tests respectively were reported.

In a study cited by Borg (14), Noble, Sherman, and Borg using 19 male university students reported the first cross-validation of the Borg Scale outside of Sweden. Subjects performed a modified Sjostrand bicycle ergometer test with four minutes duration for each progressively increased work load. Subjects also did the Balke treadmill test at a constant speed of 3.4 miles per hour with a grade increased by one percent after each minute of exercise, except for the first minute when the increase was from zero to two percent. Heart rates and ratings of perceived exertion were recorded at each work load for both tests. Correlation coefficients of 0.94 and 0.85 between heart rates and

ratings of perceived exertion on the bicycle ergometer and treadmill respectively were reported. No significant differences in the correlation coefficients between heart rates and ratings of perceived exertion for the bicycle ergometer and treadmill tests were reported which suggests that the relationship between heart rates and ratings of perceived exertion may be independent of the type of work being done.

Borg and Linderholm (15) studied the relationship between heart rates and ratings of perceived exertion of 277 subjects ranging in age from 18 to 79 years using a progressive work load test on the bicycle ergometer. The work load was started at 300 kpm./min. and was increased every sixth minute until exhaustion was reached. Heart rates and ratings of perceived exertion increased linearly with increasing work loads for all age groups. Exercise at a given work load was perceived to be heavier by the older subjects than the younger subjects. Frankenhaeuser et al. (28) studied the relationship between heart rates and ratings of perceived exertion of 10 male university students using three different work loads (150, 450, or 750 kpm./min.) on the bicycle ergometer. For each session, subjects cycled at one work load for five successive six minute periods with a six minute rest in between work periods. Heart rates were taken at the sixth minute of each of the five work periods, and ratings of perceived exertion (using the 21-point scale) were taken once at each work session. Heart rates and ratings of perceived exertion increased linearly with increasing work loads. Ratings of perceived exertion and heart rates significantly increased with each increase in work load ($p < 0.001$).

Skinner, Borg, and Buskirk (64) studied the relationship between heart rates and ratings of perceived exertion of 26 male

university students differing in activity level and body size on the bicycle ergometer. Each subject initially worked at 75 kpm./min. for four minutes and then the work load was increased to 300 kpm./min. for four minutes. Increments of 300 kpm./min. were added every four minutes until a self-imposed maximum was reached. Heart rates and ratings of perceived exertion were recorded every four minutes. Results showed a linear relationship between heart rates and ratings of perceived exertion and increasing work loads. A correlation coefficient of 0.90 between heart rates and ratings of perceived exertion were reported. Pandolf et al. (54) studied the relationship between heart rates and ratings of perceived exertion of 10 male university students. Subjects exercised on the bicycle ergometer at 40% of their maximum oxygen consumption. Heart rates were recorded after the first and fifth minute of exercise and every five minutes after that until the end of exercise. Ratings of perceived exertion were recorded after the first minute of exercise and every two and one-half minutes after that until the end of exercise. Ratings of perceived exertion and heart rates displayed a linear relationship.

Bar-or et al. (5), using 70 male subjects aged 41 to 60 years, investigated the degree of linearity of the relationship between heart rates and ratings of perceived exertion on a bicycle ergometer and a treadmill. Each subject completed a graded test on the bicycle ergometer and the treadmill up to a heart rate of 150 beats per minute. On the bicycle ergometer, the work load was started at 300 kpm./min. and was increased every two minutes until either a heart rate of 150 was reached or the exertion was rated as very hard. Work on the treadmill was started at 4.8 km./hr. at a zero percent grade with an increase in

grade every two minutes of 2.5% until either a heart rate of 150 was reached or the exertion was rated as very hard. Heart rates and ratings of perceived exertion were obtained in the last twenty seconds at each work load. Ratings of perceived exertion increased linearly with heart rates with increasing work loads on the bicycle ergometer and the treadmill. Correlation coefficients between heart rates and ratings of perceived exertion for the bicycle ergometer and the treadmill were 0.77 and 0.80 respectively.

SUMMARY OF THE RATINGS OF PERCEIVED EXERTION DURING PHYSICAL PERFORMANCES

There is a linear relationship between heart rate during exercise - a physiological indicator of physical stress, and rating of perceived exertion during exercise - a psychological indicator of physical stress (5, 10, 11, 14, 15, 28, 54, 64, 65). In normal subjects, correlation coefficients from 0.62 to 0.94 have been reported between heart rates during exercise and ratings of perceived exertion during exercise. Therefore, the subjective rating of the intensity of physical exertion, as perceived by the exercising individual, is a valid and reliable indicator of the physiological strain of physical stress.

CHAPTER III

METHODS AND PROCEDURES

SUBJECTS AND MATERIAL

A sample of twelve male athletes participated in the study. The subjects were all volunteers ranging in age from 18 to 33 years. A medical examination was completed on all subjects prior to beginning any of the testing sessions. Also, all subjects signed an informed consent form prior to participating in the study (Appendix D).

The drug used in this study was dextroamphetamine sulfate (dexedrine). Each subject received 0.14 mg. per kilogram of body weight of dexedrine (Appendix J) orally in a solution of eight ounces of orange juice.

PRELIMINARY TESTING SESSION

All subjects completed a preliminary test to determine maximum heart rate and corresponding work load on the bicycle ergometer. The test used was a progressively increased work load test. Before reporting for the test, all subjects were instructed not to ingest any food two hours prior to being tested, and not to engage in any strenuous activity the day of the test, as these two factors may affect the test results.

Prior to performing the test, all subjects read typed instructions for the testing session (Appendix E). The seat height on the bicycle ergometer was adjusted to individual preference. The individual seat heights selected by the subjects were constant for all

of the testing sessions. All subjects cycled at 60 revolutions per minute at an initial work load of one kilopond for four minutes. The work load was progressively increased every four minutes until the subject could not complete the four minute ride. At this time the subject's maximum heart rate for a corresponding work load was recorded. Heart rate and work load were recorded between three and one-half and four minutes of every work load during the test. A work load corresponding to 90% of each subject's maximum heart rate attained on the progressive work load test was determined. This work load was used for the next three testing sessions.

PROTOCOL FOR THE THREE TESTING SESSIONS

Each subject during the three testing sessions completed the test protocol once without taking either dexedrine or the placebo, once after taking dexedrine, and once after taking the placebo. The order in which the subjects received the three treatments was determined by a Latin square design. Both the placebo and the drug were administered double blind. There were two to three days between each subject's testing time and day. Each subject appeared at the same time of day for each of the three testing sessions. Prior to reporting for any of the three testing sessions, the subjects were instructed not to ingest any food three hours prior to being tested as this may affect the absorption time of the drug, and not to engage in any strenuous activity the day of the test as this may influence the test results.

The following is an explanation of the time schedule of the parameters tested during the three testing sessions:

The subject reported to the laboratory and was administered

either dexedrine in a solution of eight ounces of orange juice, the placebo, or neither the placebo or dexedrine. The subject then rested for 25 minutes. During this period, the subject read typed instructions for the three testing sessions (Appendix F). The subject then sat on the bicycle ergometer for five minutes. Resting measurements of heart rate, blood pressure, and oxygen uptake were then taken. Exercise on the bicycle ergometer was then started by a two minute warm-up at a work load of one-half to one kilopond. After the warm-up, the subject cycled at the predetermined work load at 60 revolutions per minute. Absorption of dexedrine from the gastrointestinal tract is rapid (9, 18, 29). "With the usual oral dose of 2.5 to 5.0 mg. of dextro-amphetamine, the effects appear within one-half to one hour" (9:504). Thus, the drug was administered one-half hour prior to exercise.

Exercise measurements of heart rate, blood pressure, and oxygen uptake were obtained every ten minutes until the end of exercise. As a safety precaution, heart rate was monitored at the end of every minute during the test. Recovery measurements of heart rate, blood pressure, and oxygen uptake were taken five, ten, and fifteen minutes following the end of exercise.

Each subject responded to a scale for ratings of perceived exertion every five minutes during the exercise.

Pedal revolutions were recorded every minute. The termination of exercise occurred when the subject indicated he could no longer complete the task required - that is, cycling at 60 revolutions per minute at the constant predetermined work load.

Urine samples were obtained following the fifteen minute recovery period from exercise during the testing sessions when either

dexedrine or the placebo had been administered to the subjects. The sample from the placebo session was discarded. The other sample was measured for volume produced and pH. A sample of approximately 30 ml. of urine with one-half a cc. of toluene per 10 ml. added to the urine was frozen to be analyzed for amphetamine content at a later date.

At the end of the two testing sessions when either the placebo or the dexedrine had been administered, the subjects were asked to identify whether they thought the placebo or the dexedrine had been administered.

MEASUREMENT TECHNIQUES

WORK LOAD ON THE BICYCLE ERGOMETER

The bicycle ergometer used was manufactured by the Monark Company of Sweden. The wheel of the ergometer was braked mechanically by a friction belt. The work loads (frictional force applied to the frictional belt) were obtained by adjusting the tension regulating mechanism on the bicycle ergometer. An electrical counter connected to a microswitch, which in turn was attached to the pedal axis, recorded the number of revolutions pedalled. An electrical metronome that was set at 120 beats per minute was used to assist the subject in maintaining a pedalling rate of 60 revolutions per minute.

The bicycle ergometer was calibrated, using a standard technique (37), before and after each testing session. Calibration factors were obtained by hanging standard masses on the revolving drum. The calibration factors obtained for each of the appropriate scale divisions were the number of grams required to raise the pendulum to each scale marking.

HEART RATE

Heart rate was recorded by a Sanborn 500 Viso-Cardiette Recorder (electrocardiograph). Readings were obtained from two chest electrodes and one reference electrode. The recorder was calibrated before and after each testing session.

BLOOD PRESSURE

Blood pressure was measured by a sphygmomanometer which measures the amount of air pressure equal to the blood pressure in an artery. The measurement was always taken using the right upper arm and was measured to the nearest five millimeters.

OXYGEN UPTAKE

Oxygen uptake was measured using an open circuit method. Barometric pressure and room temperature were recorded immediately prior to the start of the testing session. Expired gas samples were collected in meteorological balloons. Gas samples of one minute duration were collected for rest and recovery measurements, and fifteen second gas samples were taken during exercise. All gas volumes were corrected to STPD. The samples were analyzed immediately for oxygen and carbon dioxide content.

The Beckman Model E2 Oxygen Analyzer was used to determine the percentage of oxygen in the sample. The Godart Capnograph CO_2 Analyzer was used to determine the percentage of carbon dioxide in the sample. Both analyzers were calibrated before and after testing each subject during the testing sessions. Calibration of the analyzers was done using a reference gas (containing 5.04% carbon dioxide and 95.96% nitrogen) and room air (containing 20.94% oxygen).

RATINGS OF PERCEIVED EXERTION

Perceived exertion was measured by a scale for ratings of perceived exertion developed by G. A. V. Borg (11). A diagram of the rating scale and the verbal explanation of the scale that was read by each subject prior to the start of the testing sessions can be found in Appendix F.

ENDURANCE PERFORMANCE

Endurance performance was measured to the nearest minute by the length of time that a subject cycled at 60 revolutions per minute at a predetermined constant work load.

URINE ANALYSIS

The estimation of dextroamphetamine sulfate in the urine samples of the subjects tested was done by gas-liquid chromatography (GLC) using a flame ionization detector (FID).

Instrument: Hewlett Packard 5700A

Column: glass, 6 ft., 1/8 in. Id.

Phase and Support: 3% OV225 on Chromosorb W HP (60 - 80 mesh)

Column Temp.: 75 degrees

Injector Temp.: 250 degrees

Detector Temp.: 250 degrees

Carrier Gas: He. (12.5 psi.)

Attentuation: 10 by 8

A sample of five milliliters of urine was basified with 0.5 ml. of 20% sodium hydroxide solution. The internal standard, n-propylamphetamine, was added and the mixture was gently shaken for two

minutes with five milliliters of ether. After centrifuging, three milliliters of the ether layer were recovered, three drops of n-butanol were added and the mixture was evaporated to approximately 100 microliters in a water bath at 45 degrees centigrade. Two microliter samples of the concentrated extract were chromatographed. Results were calculated from a calibration curve that was prepared by adding known amounts of dextroamphetamine sulfate to blank urine (Appendix G - Table 52).

EXPERIMENTAL DESIGN

To determine the order in which the subjects received the three treatments, the standard form of a 3 x 3 Latin square design was used (73:688). The order of the three treatments was thus randomized under the restriction of the balance required for the Latin square design. The 12 subjects were randomly assigned to one of three groups. The three groups of four subjects each were assigned to one of the three rows of the Latin square. The three letters of the Latin square (a, b, c) were assigned to the three treatments (control, drug, placebo respectively). The following is a diagrammatical representation of the design used:

		SESSION		
		1	2	3
GROUP	A	a	b	c
	B	b	c	a
	C	c	a	b

Plan 5 for Latin square repeated measures design (73:712) was used for the parameters measured at rest and for the endurance performance times. For the parameters measured during exercise and during recovery from

exercise, plan 12 for Latin square repeated measures design (73:745) was used.

STATISTICAL TREATMENT OF THE DATA

Work loads corresponding to 90% of the subjects' maximum heart rates attained during the preliminary testing session were determined by a least squares solution (24). An APL program (Appendix B) using the equations for the linear regression of Y on X was used to ascertain the desired work loads.

An APL program (Appendix C) was used to convert the values obtained for oxygen and carbon dioxide expired gas samples to oxygen consumption in milliliters per kilogram of body weight per minute.

For most of the parameters measured, analyses of Latin square repeated measures designs were used to treat the data. For the analyses of the resting measurements and the endurance performance times, plan 5 for Latin square repeated measures design (73:712) was used. Plan 12 for Latin square repeated measures design (73:745) was used for the analyses of the exercise and recovery measurements. A one-way analysis of variance was used to treat age, height, weight, and maximum heart rate data. A t-test for correlated samples was used to compare the heart rates that were 90% of the maximum heart rates attained during the preliminary testing session (predicted heart rates) with the actual heart rates of the subjects at the tenth minute of exercise during the control session. FORTRAN programs were used to compute the results. Where applicable, a Scheffé test was used whenever significant F's occurred.

CHAPTER IV

RESULTS AND DISCUSSION

INTRODUCTION

The purpose of this study was to investigate the effects of dextroamphetamine sulfate on selected physiological, psychological, and physical performance parameters of male athletes in the noncompetitive season. A sample of 12 volunteer male athletes were studied.

The statistical analyses of the data are presented in Appendix A (Tables 9 - 51). In the analyses, the terms group, treatment, session, and time refer to the following: 1) Group - The subjects were randomly assigned to one of three groups (A, B, or C). Groups A, B, and C were comprised of subjects 1 - 4, 5 - 8, and 9 - 12 respectively.

2) Treatment - refers to the three treatments (control, drug, and placebo) which the subjects were administered. Treatments 1, 2, and 3 refer to control, drug, and placebo conditions respectively.

3) Session - refers to the three different occasions that the subjects were tested following administration of one of the three treatments. Therefore, sessions 1, 2, and 3 refer to the first, second, and third occasions respectively that the subjects were tested.

4) Time - refers to the specific time periods during which measurements were taken on the parameters studied. For the parameters measured during exercise, times 1 and 2 refer to the measurements taken at 10 minutes of exercise and the end of exercise

respectively. For the parameters measured during recovery from exercise, the measurements were taken 5, 10, and 15 minutes following the end of exercise (Times 1, 2, and 3 respectively). The only exception in the use of the term time is with the comparisons of parameters measured at rest and during the fifteenth minute of recovery from exercise. For these comparisons, time 1 refers to the measurements taken at rest and time 2 refers to the measurements taken during the fifteenth minute of recovery from exercise.

The graphs, as presented in this chapter, illustrate all treatment effects and all significant effects for the analyses of the parameters measured at rest, during exercise, and during recovery from exercise. Unless otherwise stated, 0.05 has been used as the level of significance for any significant differences reported in this chapter. Comparisons with the results reported were done only with those studies reviewed in the literature that used various doses of dextroamphetamine sulfate. However, it must be noted that these studies not only used various doses of the drug but also different number and type of subjects, different methods of administering the drug, different times allowed for absorption of the drug prior to measuring the parameters tested, and different physical performances. Any one of these factors may have attributed to the results of these studies reported in this chapter.

PHYSICAL CHARACTERISTICS OF SUBJECTS

Table 1 presents the means and ranges for age, height, weight, and maximum heart rate of the subjects tested. These parameters were measured during the preliminary testing session. The physical

characteristics for each subject are presented in Table 55 (Appendix K). One-way analysis of variance for each of the physical characteristics reported in Table 1 revealed no significant differences between groups for any of the characteristics (Appendix A - Tables 9, 10, 11, 12).

TABLE 1

PHYSICAL CHARACTERISTICS OF SUBJECTS

Parameter	Unit of Measurement	Mean	Range
Age	Years	25.22	18.33 - 33.17
Height	Centimeters	176.51	164.0 - 190.5
Weight	Kilograms	76.45	69.3 - 95.0
Maximum Heart Rate	Beats per Minute	181.75	167 - 195

PRELIMINARY TESTING SESSION

From the data of the preliminary testing session (Appendix K - Table 75) the predicted work loads for all of the subjects were determined using an APL program (Appendix B) for the linear regression of Y on X. These work loads corresponded to 90% of the subjects' maximum heart rates attained during the progressive work load test. These work loads were used for testing the subjects for the next three testing sessions. Table 2 gives the predicted work loads for all of the subjects tested.

TABLE 2

WORK LOADS FOR THE THREE TESTING SESSIONS

Subject Number	Predicted Work Loads (Kilopond)
1	3.75
2	3.50
3	3.50
4	3.50
5	4.25
6	3.50
7	4.00
8	3.75
9	3.25
10	3.75
11	3.75
12	3.50

THREE TESTING SESSIONS

Summaries of the analyses of the parameters measured at rest, during exercise, and during recovery from exercise are presented in Tables 3, 4, and 5 respectively. Table 6 provides a summary of the analyses of comparisons of parameters measured at rest and during the fifteenth minute of recovery from exercise. A "-" appearing in the tables indicates no significant differences, and an "*" appearing in the tables indicates significant differences for the three testing sessions.

TABLE 3

SUMMARY OF ANALYSES FOR PARAMETERS MEASURED AT REST

Parameter	Session	Treatment	Session x Treatment
Heart Rate	-	-	-
Systolic Blood Pressure	-	-	-
Diastolic Blood Pressure	-	-	-
Oxygen Uptake	-	-	-

- Not Significant at the 0.05 level

TABLE 4

SUMMARY OF ANALYSES FOR PARAMETERS MEASURED DURING EXERCISE

Parameter	Session	Treatment	Treatment x Session	Time	Time x Groups	Session x Time	Treatment x Time	Treatment x Session x Time
Heart Rate	*	*	-	*	-	-	-	-
Systolic Blood Pressure	-	-	-	-	-	-	-	-
Diastolic Blood Pressure	*	-	*	-	-	-	-	-
Oxygen Uptake	*	-	-	*	-	-	-	-
Perceived Exertion	-	-	-	*	*	-	-	-
Endurance Performance Time	*	-	-					

* Significant at the 0.05 level
- Not Significant at the 0.05 level

TABLE 5

SUMMARY OF ANALYSES FOR PARAMETERS MEASURED DURING RECOVERY FROM EXERCISE

Parameter	Session	Treatment	Treatment x Session	Time	Time x Groups	Session x Time	Treatment x Time	Treatment x Session x Time
Heart Rate	-	*	-	*	-	-	-	-
Systolic Blood Pressure	*	*	-	*	-	-	-	-
Diastolic Blood Pressure	-	-	-	-	-	-	-	-
Oxygen Uptake	*	*	-	*	-	-	-	-

* Significant at the 0.05 level
- Not Significant at the 0.05 level

TABLE 6

SUMMARY OF THE ANALYSES OF COMPARISONS OF PARAMETERS MEASURED AT REST AND DURING THE FIFTEENTH MINUTE OF RECOVERY FROM EXERCISE

Parameter	Session	Treatment	Treatment x Session	Time	Time x Groups	Session x Time	Treatment x Time	Treatment x Session x Time
Heart Rate	-	*	-	*	-	-	*	-
Systolic Blood Pressure	*	-	-	*	-	-	-	-
Diastolic Blood Pressure	*	-	-	*	-	-	-	-
Oxygen Uptake	-	-	-	*	-	-	-	-

* Significant at the 0.05 level
- Not Significant at the 0.05 level

PARAMETERS MEASURED AT REST

HEART RATE AT REST

Table 13 (Appendix A) summarizes the analysis of variance for heart rate measured at rest. No significant differences for heart rate at rest occurred among the three treatments. Thus, dexedrine had no significant effect on resting heart rate. This result is in agreement with that reported by Goldstein, Searle, and Schimke (32); and Snyder, Faillace, and Weingartner (68). However, Golding and Barnard (31); Martin *et al*. (50); and Segers, s'Jongers, and Lewillie (62) reported increases in heart rate at rest as result of dexedrine administration. Figure 1 illustrates the mean resting heart rate values for the three treatments.

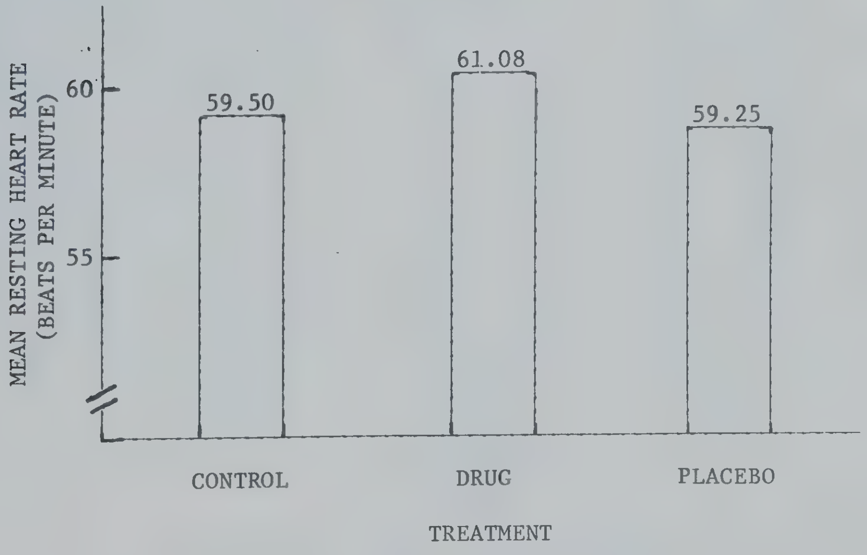


FIGURE 1

MEAN RESTING HEART RATE VALUES FOR THE THREE TREATMENTS

SYSTOLIC BLOOD PRESSURE AT REST

The analysis of variance for systolic blood pressure measured at rest is summarized in Table 14 (Appendix A). There were no significant differences among the three treatments for systolic blood pressure at rest. Thus, dexedrine had no significant effect on systolic blood pressure at rest. This result is in agreement with that reported by Goldstein, Searle, and Schimke (32); Segers, s'Jongers, and Lewillie (62); and Snyder, Faillace, and Weingartner (68). An increase in systolic blood pressure at rest was reported by Golding and Barnard (31). Figure 2 illustrates the mean resting systolic blood pressure values for the three treatments.

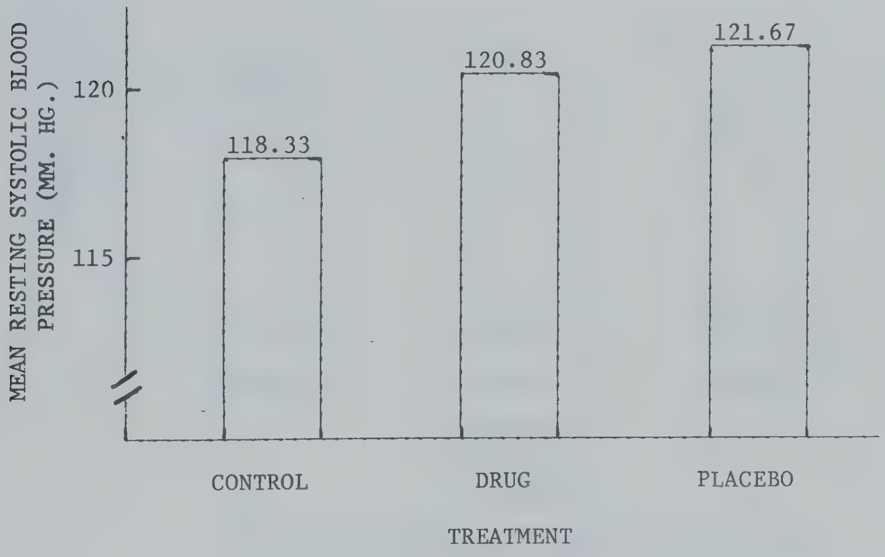


FIGURE 2

MEAN RESTING SYSTOLIC BLOOD PRESSURE VALUES
FOR THE THREE TREATMENTS

DIASTOLIC BLOOD PRESSURE AT REST

Table 15 (Appendix A) presents the analysis of variance for diastolic blood pressure measured at rest. No significant differences occurred in diastolic blood pressure at rest among the three treatments. Thus, dexedrine had no significant effect on diastolic blood pressure at rest. This result is in agreement with that reported by Goldstein, Searle, and Schimke (32); Segers, s'Jongers, and Lewillie (62); and Snyder, Faillace, and Weingartner (68). Figure 3 illustrates the mean resting diastolic blood pressure values for the three treatments.

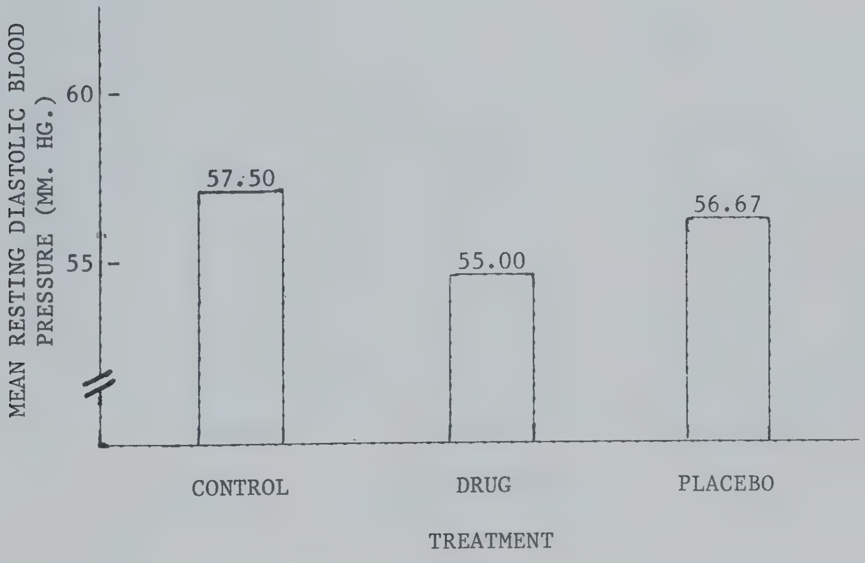


FIGURE 3

MEAN RESTING DIASTOLIC BLOOD PRESSURE VALUES FOR THE THREE TREATMENTS

OXYGEN UPTAKE AT REST

The analysis of variance for oxygen uptake measured at rest is summarized in Table 16 (Appendix A). There were no significant differences in oxygen uptake at rest among the three treatments. Thus, dexedrine had no significant effect on oxygen uptake at rest. Segers, s'Jongers, and Lewillie (62) reported an increase in oxygen uptake at rest. Figure 4 graphically depicts the mean resting oxygen uptake values for the three treatments.

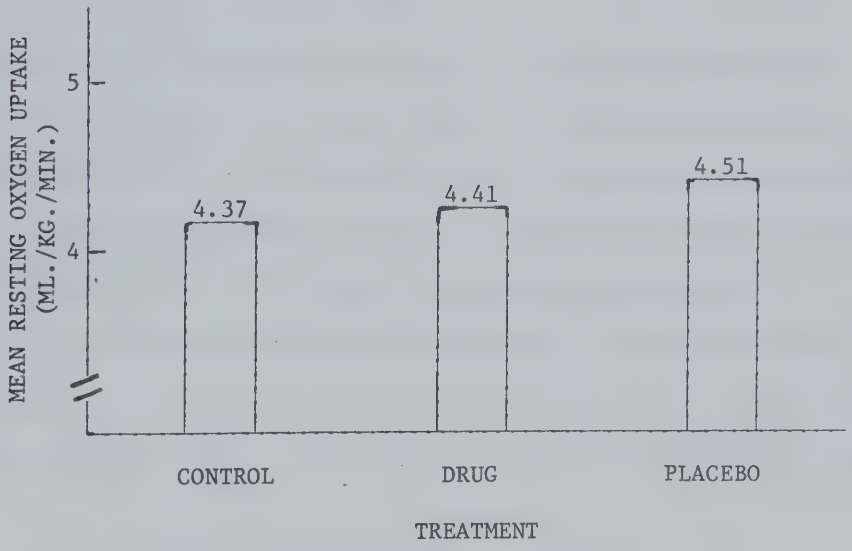


FIGURE 4

MEAN RESTING OXYGEN UPTAKE VALUES FOR THE THREE TREATMENTS

SUMMARY OF THE PARAMETERS MEASURED AT REST

Dextroamphetamine sulfate in the dose of 0.14 mg. per kilogram of body weight had no significant effects on heart rate, systolic blood pressure, diastolic blood pressure, or oxygen uptake measured at rest. These results can be expected as the dominant action of dexedrine is as a central nervous system stimulant with weak peripheral sympathomimetic effects (and in particular cardiovascular effects) as secondary (17, 19, 29, 33, 34, 45, 47). As the drug's main attribute as a central nervous system stimulant is the masking of the physiological sense of fatigue (21, 30, 33, 44, 45, 47, 52, 53), it would seem that it is necessary to be in a state of fatigue before the drug could possibly have any effects on physiological parameters. As the subjects were not fatigued when the parameters were measured at rest, the results reported could be anticipated. However, it must be noted that at least two other factors may have caused no significant effects on the parameters measured at rest. The dose of the drug and the time allowed for absorption of the drug (30 minutes) may not have been sufficient enough to cause any significant effects.

PARAMETERS MEASURED DURING EXERCISE

ENDURANCE PERFORMANCE TIME

The analysis of variance for endurance performance times on the bicycle ergometer is summarized in Table 17 (Appendix A). No significant differences occurred in the length of time that the subjects cycled at the constant work loads for the three treatments. Thus, dexedrine had no significant effect on endurance performance time. Golding and Barnard (31) reported no significant effects on treadmill

running times of subjects who had been administered dexedrine. Figure 5 illustrates the mean endurance performance times for the three treatments. It is interesting to note that there are similar differences in times from the control to placebo treatments compared to the placebo and drug treatments. Although there were no significant differences in endurance performance times for the three treatments, the effect of being administered the drug as compared to the control condition had twice the effect of being administered the placebo as compared to the control condition.

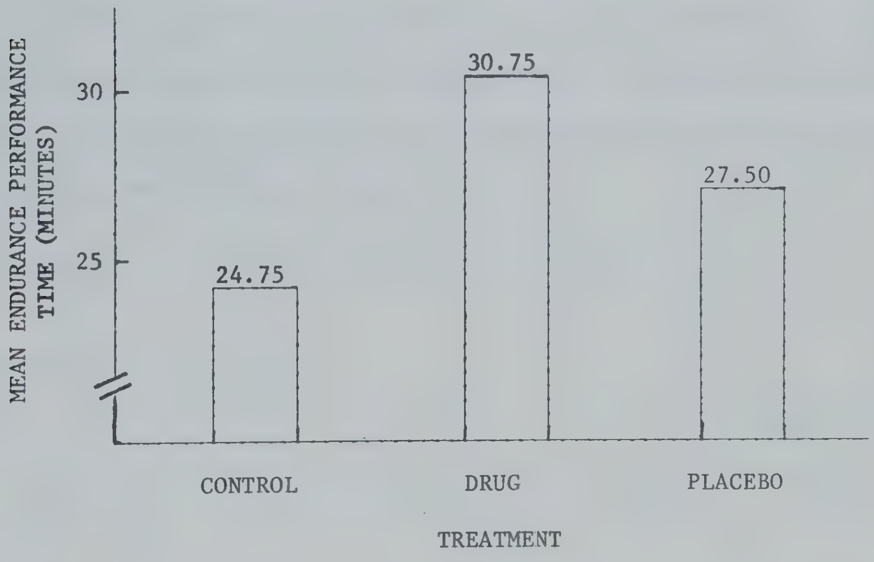


FIGURE 5

MEAN ENDURANCE PERFORMANCE TIMES FOR THE THREE TREATMENTS

The analysis revealed a significant session effect independent of the treatment administered. A Scheffé test (Appendix A - Table 18) revealed a significant difference in endurance time from session two to session three, but not from session one to session two, or from

session one to session three. Figure 6 illustrates the mean endurance performance times for the three sessions. The longest mean endurance time occurred during session three. Attributing to this result could be the realization by the subjects that this was the last testing session. The subjects used in this study were intrinsically motivated. Thus, they were all concerned with bettering their own times. The third session was the last opportunity to perform better than the previous two sessions. Although the subjects were not told their actual performance times, they could quite easily subjectively estimate their times. Although the subjects were in fairly good physical condition, none of them were presently training on the bicycle ergometer. Therefore, it is possible that the specificity of training effects from cycling on the bicycle ergometer could have attributed to the longest cycling time during session three.

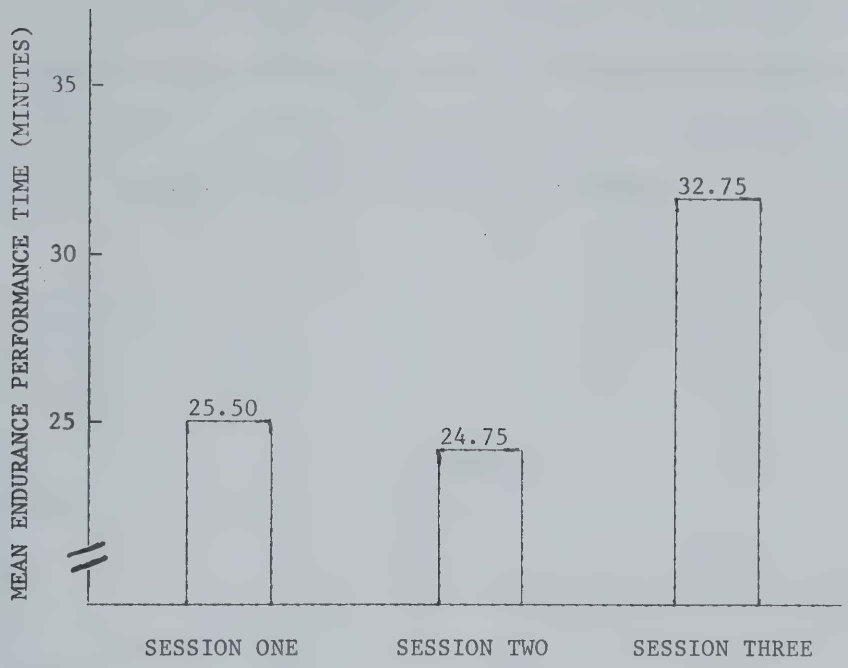


FIGURE 6

MEAN ENDURANCE PERFORMANCE TIMES FOR THE THREE SESSIONS

HEART RATE DURING EXERCISE

Table 19 (Appendix A) presents the analysis of variance for heart rate measured during exercise. Significant F's were obtained for treatment, time, and session effects. A Scheffé test (Appendix A - Table 20) for treatment effects on heart rate showed that the drug treatment was significantly different from both the placebo and control treatments, but there was no significant difference in heart rate between the control and placebo treatments. Thus, dexedrine produced a significant increase in heart rate during exercise. This result is in agreement with that reported by Segers, s'Jongers, and Lewillie (62). This increase in heart rate may cause additional stress to be placed on

the individual who is already naturally stressed by the exercise. This may be harmful to the individual in that he may be stressed beyond his natural physiological limitations. Figure 7 illustrates the mean heart rate values during exercise for the three treatments.

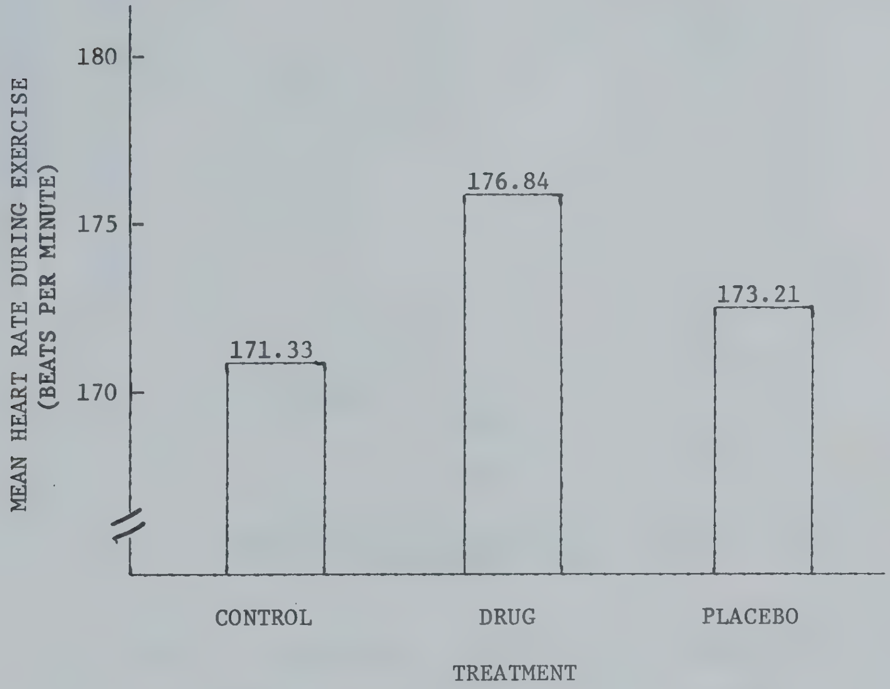


FIGURE 7

MEAN HEART RATE VALUES DURING EXERCISE
FOR THE THREE TREATMENTS

A significant time difference in heart rate at ten minutes of exercise and the end of exercise, independent of treatment, is to be expected. Heart rate obviously increases as the duration of exercise increases and fatigue sets in. Figure 8 illustrates the mean heart rate values, independent of treatment, measured at two times during exercise - 10 minutes of exercise, and the end of exercise.

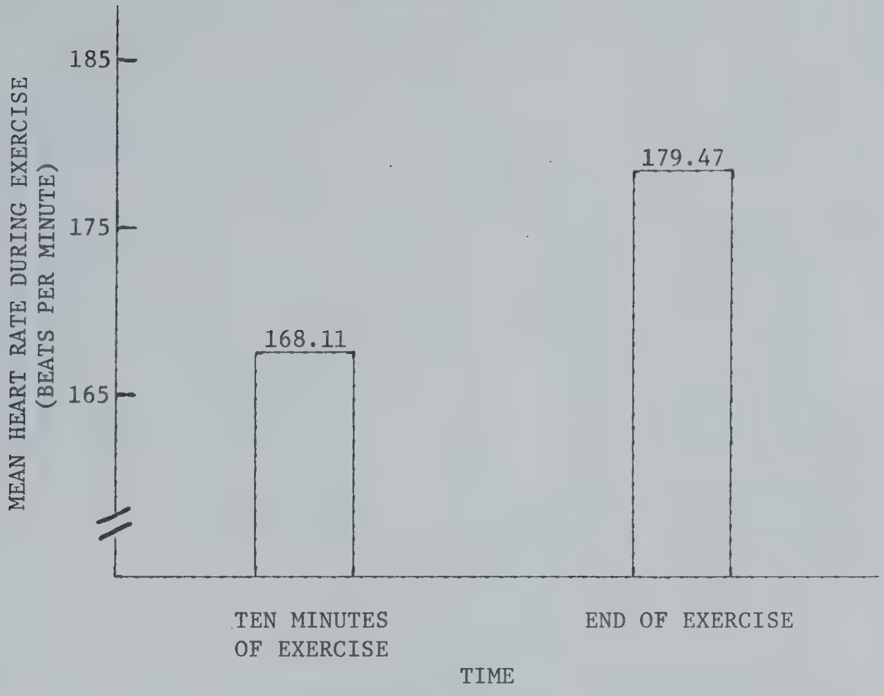


FIGURE 8

MEAN HEART RATE VALUES DURING EXERCISE
FOR THE TWO TIMES

A Scheffé test (Appendix A - Table 21) for session effects on heart rate during exercise showed that session one, independent of treatment, was significantly different from session three; there were no significant differences from session one to session two, and from session two to session three. Mean heart rate during exercise for session one was significantly higher than mean heart rate during exercise for session three. Although significant differences in heart rate for the three sessions were not expected, it is possible that the decrease in heart rate occurred as a result of the specificity of training effects from cycling on the bicycle ergometer from session one to session three (4). Figure 9 illustrates the mean heart rate values

during exercise for the three testing sessions.

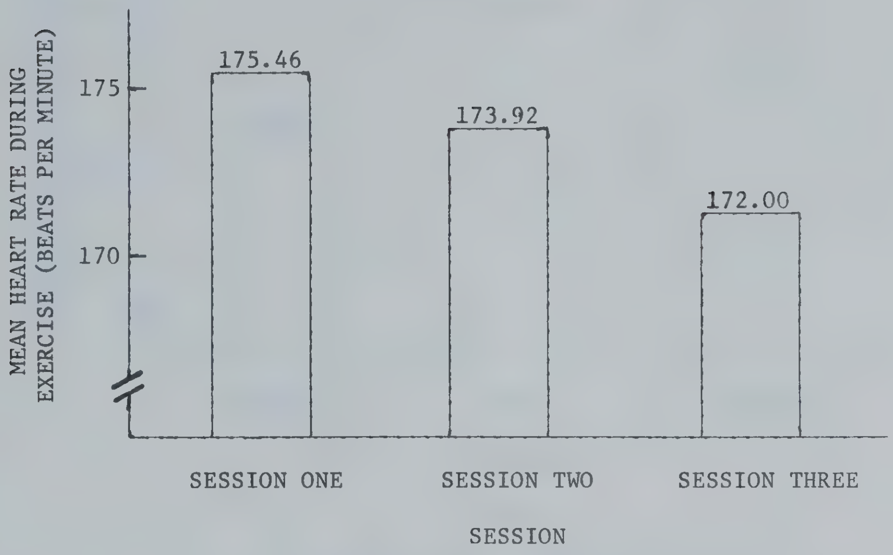
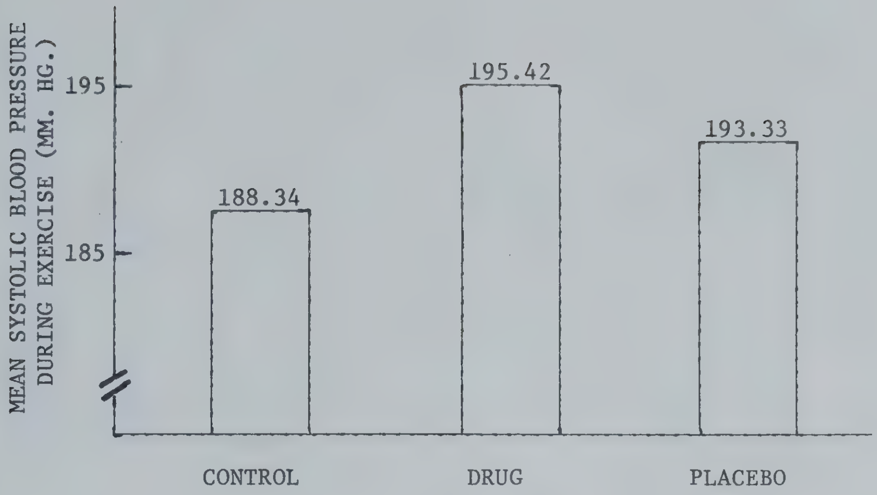


FIGURE 9

MEAN HEART RATE VALUES DURING EXERCISE
FOR THE THREE SESSIONS

SYSTOLIC BLOOD PRESSURE DURING EXERCISE

The analysis of variance for systolic blood pressure measured during exercise is summarized in Table 22 (Appendix A). There were no significant differences in systolic blood pressure during exercise in the analysis used. Dexedrine had no significant effect on systolic blood pressure during exercise. Segers, s'Jongers, and Lewillie (62) reported an increase in systolic blood pressure during exercise. Figure 10 illustrates the mean systolic blood pressure values during exercise for the three treatments.



TREATMENT

FIGURE 10

MEAN SYSTOLIC BLOOD PRESSURE VALUES DURING EXERCISE FOR THE THREE TREATMENTS

DIASTOLIC BLOOD PRESSURE DURING EXERCISE

Table 23 (Appendix A) presents the analysis of variance for diastolic blood pressure measured during exercise. There were no significant differences in diastolic blood pressure during exercise among the three treatments. Thus, dexedrine had no significant effect on diastolic blood pressure during exercise. This result is in agreement with that reported by Segers, s'Jongers, and Lewillie (62). Figure 11 illustrates the mean diastolic blood pressure values during exercise for the three treatments.

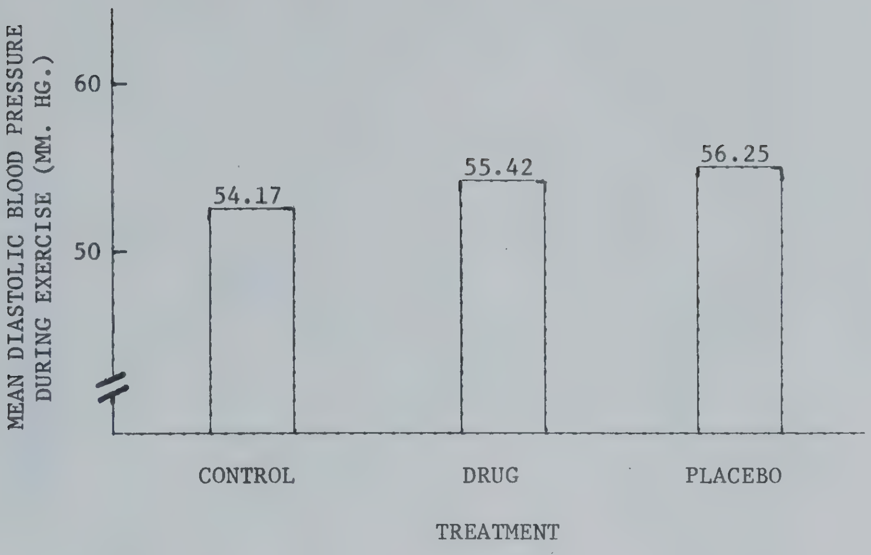


FIGURE 11

MEAN DIASTOLIC BLOOD PRESSURE VALUES DURING EXERCISE FOR THE THREE TREATMENTS

Significant F's were obtained for session effects and treatment by session interaction. A Scheffé test (Appendix A - Table 24) for session effects on diastolic blood pressure during exercise showed that mean diastolic blood pressure was significantly different from session two to session three, but not from session one to session two, or from session one to session three. A significant difference in diastolic blood pressure from session two to session three was not expected. Although the effects of training on diastolic blood pressure are not known, it is possible that the specificity of training effects from cycling on the bicycle ergometer could have attributed to the decrease observed in diastolic blood pressure during exercise for session three along with the confounding effects of treatment as illustrated in the treatment by session interaction. Figure 12 illustrates the mean diastolic blood pressure values during exercise for the three sessions.

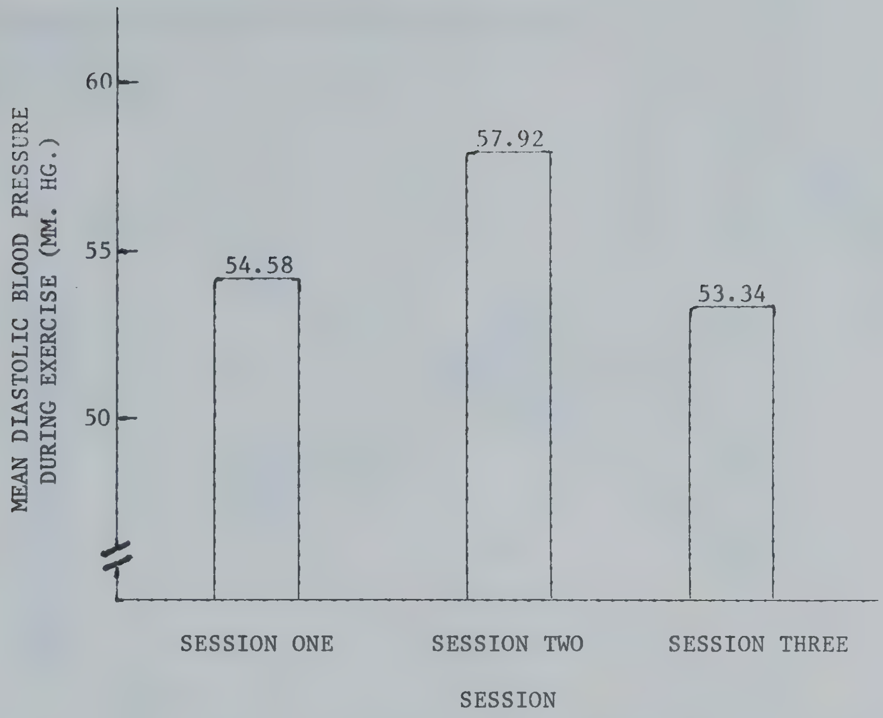


FIGURE 12

MEAN DIASTOLIC BLOOD PRESSURE VALUES DURING
EXERCISE FOR THE THREE SESSIONS

Table 25 (Appendix A) shows the significant session by treatment interactions revealed by a Scheffé test. Figure 13 illustrates the session by treatment interaction effects. For the interaction effects, the 0.10 level of significance was used for the Scheffé test. With the larger number of means (nine) there was more likelihood of finding significant differences that existed using the lower level of significance. The main effects for session and treatment were not independent of each other as illustrated by the disordinal interaction. Although diastolic blood pressure at session two was significantly different from diastolic blood pressure at session three, the effect was not independent of treatment. That is, the

treatments did not produce consistent effects from session two to session three.

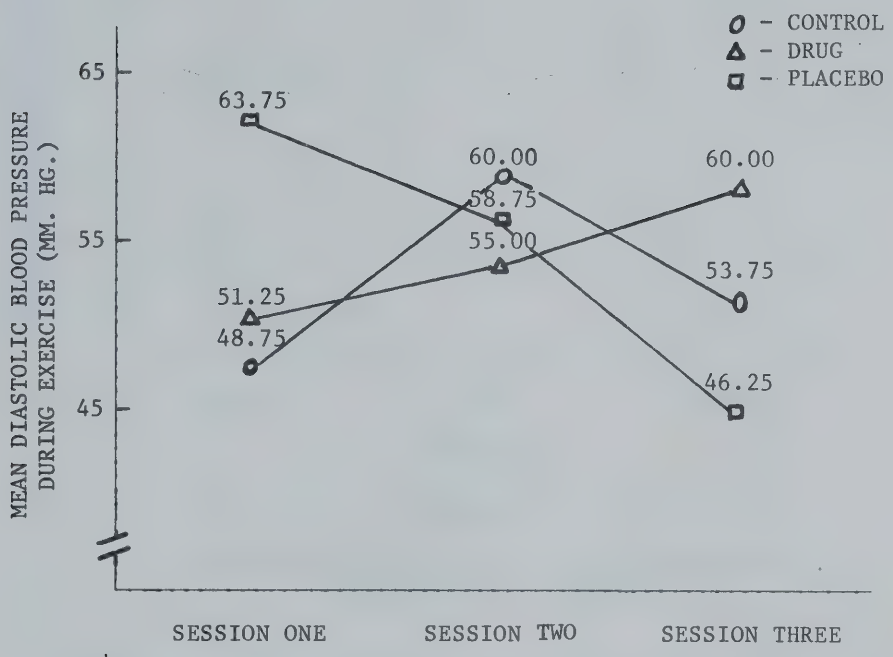


FIGURE 13

MEAN DIASTOLIC BLOOD PRESSURE VALUES DURING EXERCISE FOR SESSION X TREATMENT INTERACTION

OXYGEN UPTAKE DURING EXERCISE

The analysis of variance for oxygen uptake during exercise is summarized in Table 26 (Appendix A). There were no significant differences in oxygen uptake during exercise among the three treatments. Thus, dexedrine had no significant effect on oxygen uptake during exercise. Segers, s'Jongers, and Lewillie (62) reported an increase in oxygen uptake during exercise following dexedrine administration. Figure 14 illustrates the mean oxygen uptake values during exercise for

the three treatments.

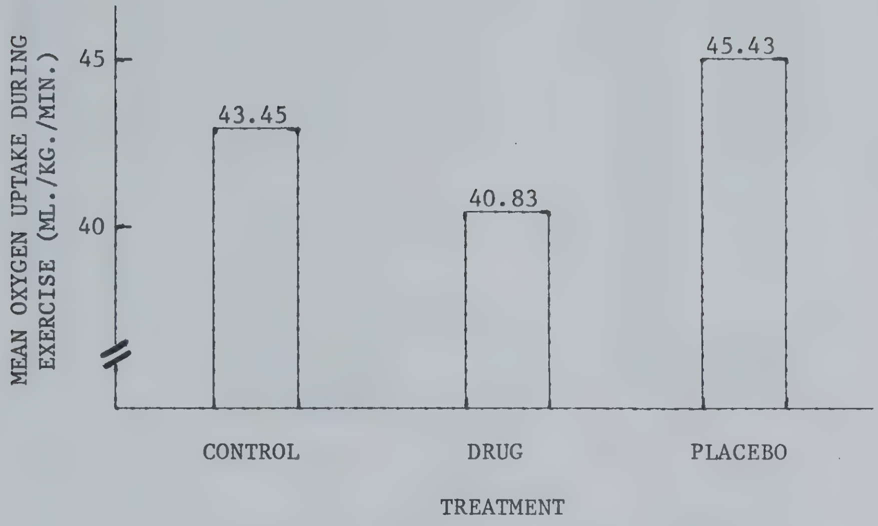


FIGURE 14

MEAN OXYGEN UPTAKE VALUES DURING EXERCISE
FOR THE THREE TREATMENTS

Significant F's were obtained for session and time effects. A significant difference in oxygen uptake at ten minutes of exercise and at the end of exercise, independent of treatment, is to be expected. Oxygen uptake increases as the duration of exercise increases and fatigue sets in. Figure 15 illustrates the mean oxygen uptake values, independent of treatment, measured at two times during exercise - 10 minutes of exercise and the end of exercise.

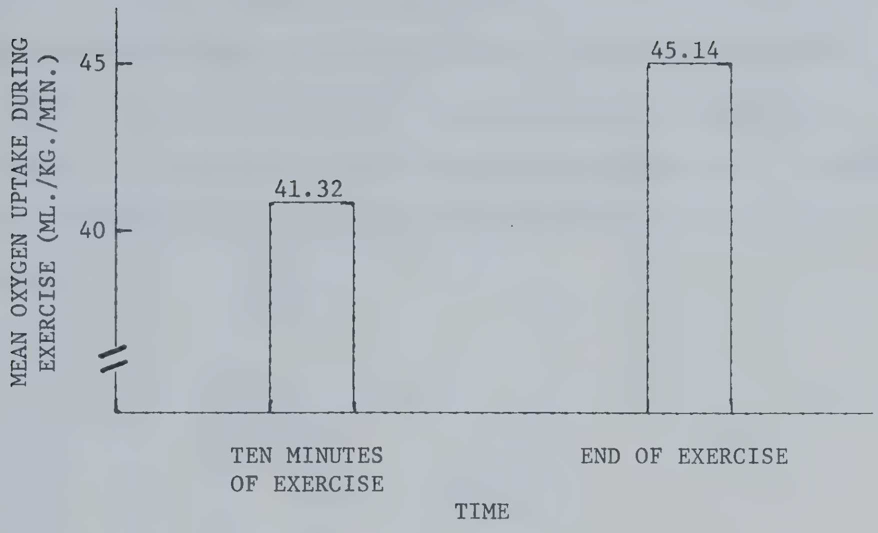


FIGURE 15

MEAN OXYGEN UPTAKE VALUES DURING EXERCISE
FOR THE TWO TIMES

A Scheffé test (Appendix A - Table 27) for session effects on oxygen uptake during exercise showed that session one, independent of treatment, was significantly different from session three; but there were no significant differences from session one to session two, or from session two to session three. The Scheffé was computed using 0.10 as the level of significance. The analysis (Appendix A - Table 26) revealed a significant F of 3.21 for session effects. However, this F is too close to the critical value of F required for significance (3.20) to find where the significant session effect is using the 0.05 level of significance for the Scheffé test. Therefore, 0.10 was used as the level of significance in this analysis. Mean oxygen uptake during exercise for session one was significantly higher than mean oxygen uptake during exercise for session three. A significant difference in oxygen uptake from session one to session three was not

expected. This difference in oxygen uptake from session one to session three could be attributed to the specificity of training effects from cycling on the bicycle ergometer as oxygen uptake decreases with training for a given work load on the bicycle ergometer (4). Figure 16 illustrates the mean oxygen uptake values during exercise for the three sessions.

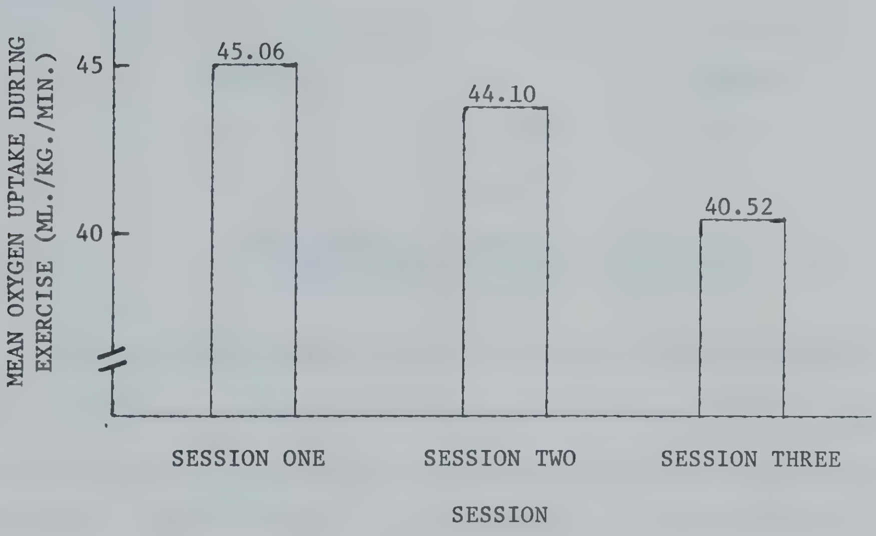


FIGURE 16

MEAN OXYGEN UPTAKE VALUES DURING EXERCISE
FOR THE THREE SESSIONS

PERCEIVED EXERTION DURING EXERCISE

Table 28 (Appendix A) presents the analysis of variance for perceived exertion during exercise. There were no significant differences in ratings of perceived exertion for the three treatments. Thus, dexedrine had no significant effect on the subjects' perception of the physical work they were doing. Figure 17 illustrates the mean perceived exertion values during exercise for the three treatments.

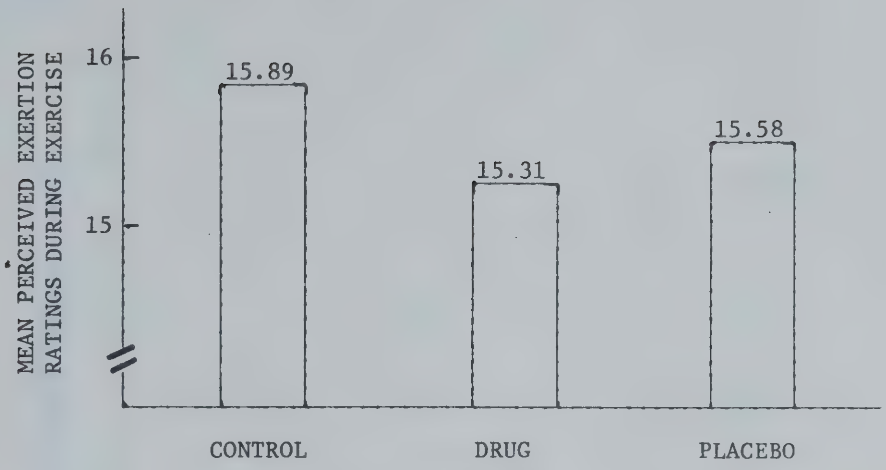
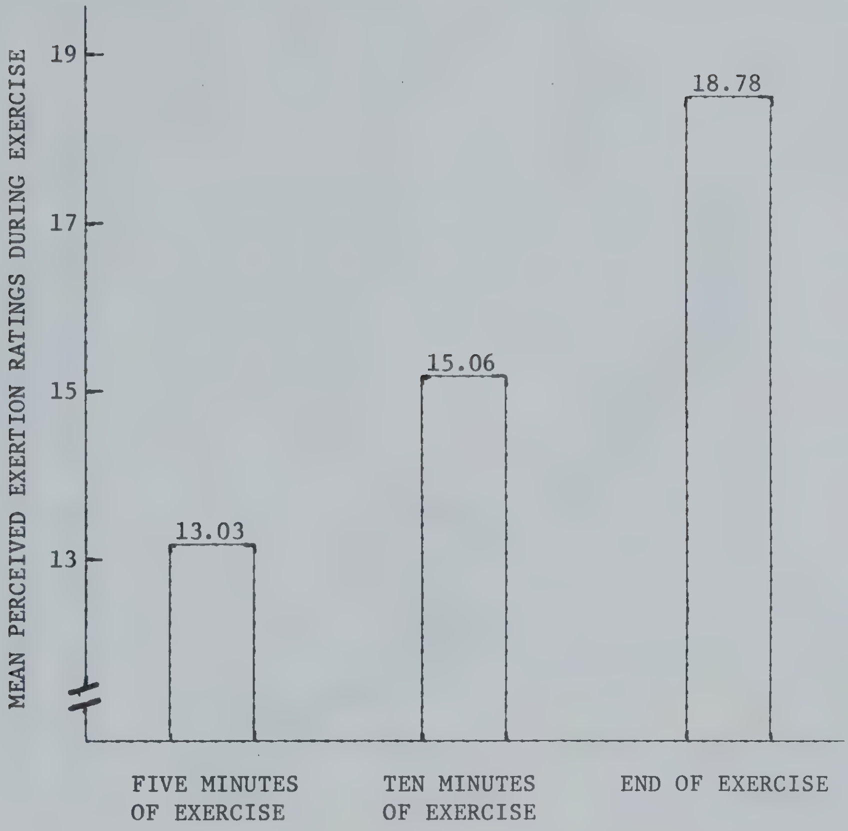


FIGURE 17

MEAN PERCEIVED EXERTION VALUES DURING EXERCISE FOR THE THREE TREATMENTS

Significant F's were obtained for time effects and time by group interaction. A Scheffé test (Appendix A - Table 29) for time effects on ratings of perceived exertion during exercise showed that time two was significantly greater than time one; time three was significantly greater than time one; and time three was significantly greater than time two. The significant time effects, independent of treatment, could be anticipated. As the length of time an individual is exercising at a high work level increases, the harder the work becomes, and thus, the work is rightly perceived as being harder. A progressive increase in the perception of the work being done is shown from five minutes of exercise to ten minutes of exercise to the end of exercise. Figure 18 illustrates the mean perceived exertion values, independent of treatment, measured at three times during exercise - five minutes of exercise, ten minutes of exercise, and the end of

exercise.



TIME

FIGURE 18

MEAN PERCEIVED EXERTION VALUES DURING EXERCISE FOR THE THREE TIMES

Table 30 (Appendix A) shows the significant time by group interactions using 0.10 as the level of significance for the Scheffé test. Figure 19 illustrates the time by group interaction effects. The main effects for time and group are not independent of each other as illustrated by the disordinal interaction. Although perceived exertion ratings during exercise were significantly different from time one to

time two to time three, the effects were not independent of groups. That is, the groups did not produce consistent results for the three times.

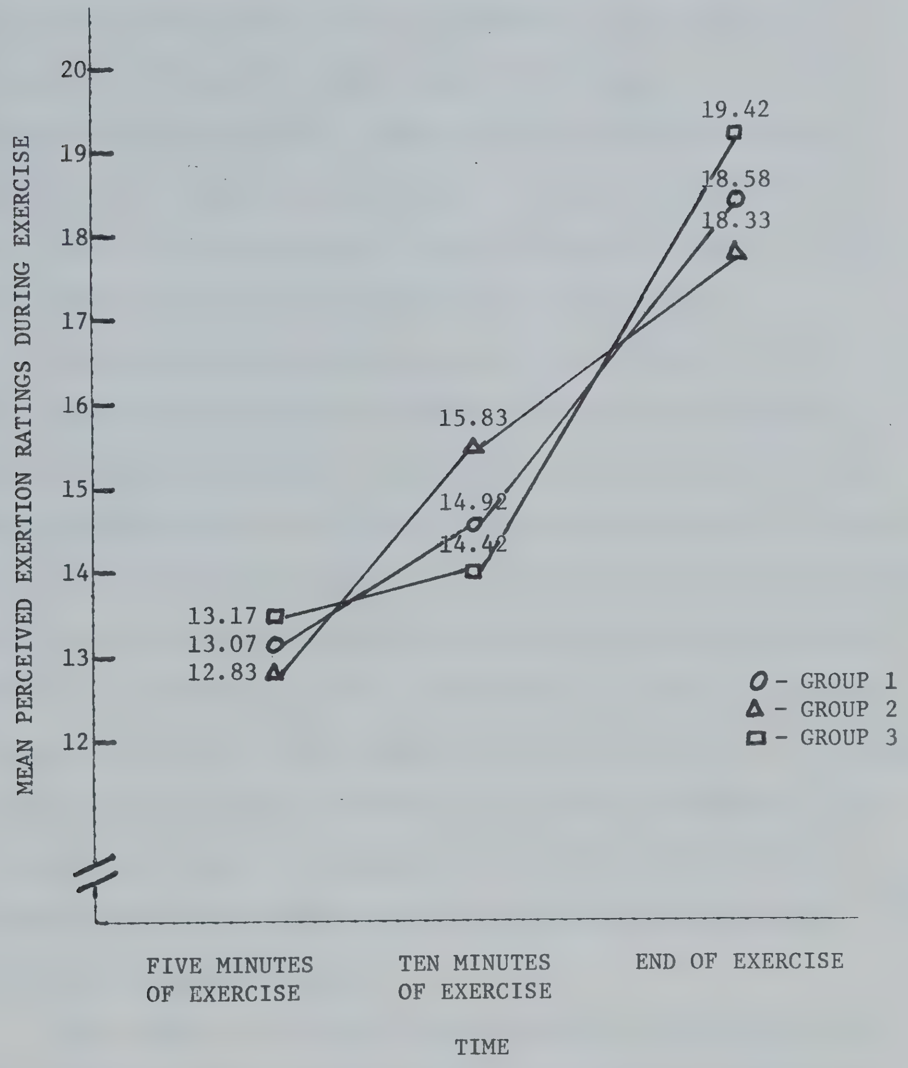


FIGURE 19

MEAN PERCEIVED EXERTION VALUES DURING EXERCISE
FOR TIME X GROUP INTERACTION

SUMMARY OF THE PARAMETERS MEASURED DURING EXERCISE

Dextroamphetamine sulfate in the dose of 0.14 mg. per kilogram of body weight, administered thirty minutes prior to exercising, had no significant effect on the length of time the subjects could cycle at the constant predetermined work loads. Systolic blood pressure, diastolic blood pressure, oxygen uptake, and ratings of perceived exertion measured at specific times during exercise on the bicycle ergometer were not significantly affected by the drug administered. Heart rate was the only parameter measured during exercise that was significantly affected by the administration of the drug.

The rating scale for perceived exertion during exercise on the bicycle ergometer was used as a measure of the degree to which the dexedrine masked the subjects' perceptions of physical exertion and the physiological sense of fatigue. Although the ratings of perceived exertion for the three treatments were not significantly different, the lowest ratings of perceived exertion for the same work load occurred during drug administration. This indicates that although the drug did not significantly affect the ratings of perceived exertion, it did have an effect in comparison to the other two treatment conditions. Thus, the drug appears to have distorted, to an extent, the subjects' perceptions of physical exertion and thus mask, to a degree, the physiological sense of fatigue.

This masking of fatigue can be exemplified with some of the other parameters measured during exercise on the bicycle ergometer. Heart rate was significantly higher after administration of the drug as compared to the placebo and control treatments. The highest systolic blood pressure value occurred during drug administration. With the

higher values reported for systolic blood pressure and heart rate under the drug treatment, it appears that the drug was masking the physiological strain of exertion. Although the subjects were being physiologically taxed with respect to heart rate and systolic blood pressure to a greater extent under the drug treatment, the longest cycling time occurred during drug administration.

The lowest oxygen uptake value occurred during drug administration. Under the influence of the drug, it appears that a masking of physiological strain with respect to oxygen uptake did not occur, or the highest value for oxygen uptake would have been reported during drug administration. However, the lowest value reported for oxygen uptake during drug administration could possibly be interpreted as meaning that the physical exertion was, in fact, less demanding on oxygen needs during the drug treatment. That is, the subjects were cycling on the bicycle ergometer more efficiently for the same work load with respect to oxygen demands during the drug treatment as compared to the placebo and control treatments.

The highest value for diastolic blood pressure occurred not during the drug treatment but during the placebo treatment. Exercise exerts little, if any, effect on diastolic blood pressure; and thus, the drug possibly exerts less effect on diastolic blood pressure during exercise than on any of the other parameters measured.

The preceding discussion has served to point out that dexedrine by masking or distorting, to an extent, the perception of exertion, physical performance and physiological parameters may be affected. The subjects maintained endurance performance for a longer period of time under the drug treatment even though they were physiologically

fatigued. Thus, the perception of exertion was masked to some extent but the physiological fatigue was not abolished. This masking of physiological fatigue may be dangerous to the athlete as further strain may be placed on the physiological processes (heart rate and systolic blood pressure in particular) that are already naturally strained by physical exertion; and the athlete may be strained beyond his natural physiological limitations.

It should be noted that no significant effects occurred with any of the physiological parameters measured during exercise (except for heart rate) possibly because dexedrine exerts weak peripheral sympathomimetic effects. However, cardiovascular effects would be exerted indirectly through the masking of fatigue. Therefore, if the dose of the drug used was greater, it is possible that the masking of fatigue would have been more explicit and thus the physiological parameters may have been significantly affected. Also, the physical performance parameter may have been significantly affected by a greater drug dose.

PARAMETERS MEASURED DURING RECOVERY FROM EXERCISE

HEART RATE DURING RECOVERY FROM EXERCISE

The analysis of heart rate measured during recovery from exercise is presented in Table 31 (Appendix A). Significant F's were obtained for treatment and time effects. A Scheffé test (Appendix A - Table 32) for treatments effects on heart rate during recovery from exercise showed that the drug treatment was significantly different from both the control and placebo treatments, but there was no significant difference between the control and placebo treatments.

Thus, dexedrine caused the heart rate to remain elevated during fifteen minutes of recovery from exercise. This result is interesting with respect to athletics. It may be harmful to athletes, under the effects of dexedrine, to have their heart rates remain elevated for a longer period of time than naturally occurs following exercise. It is not physiologically sound to place more strain on the heart than is necessary. Figure 20 illustrates the mean heart rate values during recovery from exercise for the three treatments. This result is in agreement with that reported by Golding and Barnard (31); and Segers, s'Jongers, and Lewillie (62) following drug administration. Golding and Barnard (31) reported no significant effect of dexedrine on recovery heart rate following the first all-out treadmill run, but reported a significant drug effect following the second all-out treadmill run.

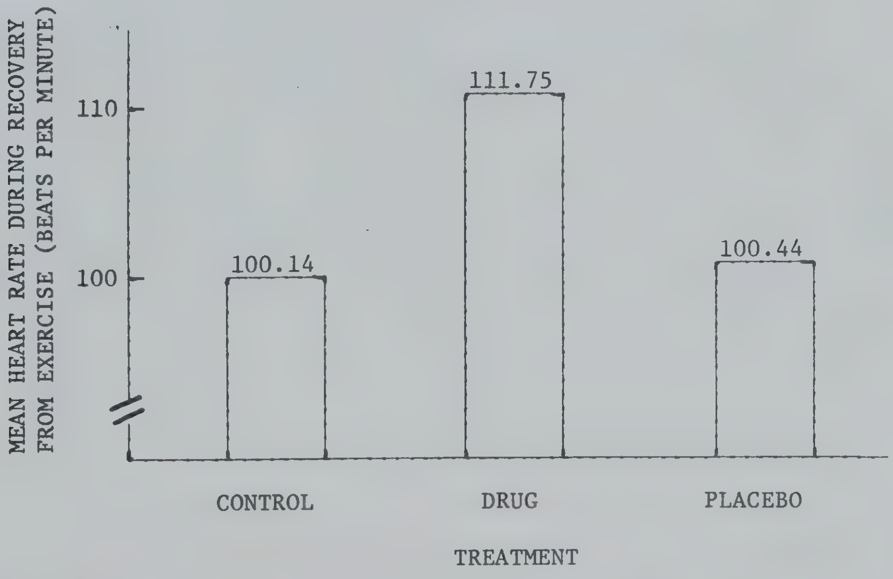


FIGURE 20

MEAN HEART RATE VALUES DURING RECOVERY FROM EXERCISE FOR THE THREE TREATMENTS

A Scheffé test (Appendix A - Table 33) for time effects on heart rate during recovery from exercise, independent of treatment, showed that time one (five minutes after the end of exercise) was significantly higher than time two (ten minutes after the end of exercise); time one was significantly higher than time three (fifteen minutes after the end of exercise); and time two was significantly higher than time three. Although heart rate decreased as would be expected from five minutes following the end of exercise to fifteen minutes following the end of exercise, independent of treatment, the dexedrine caused the heart rate to be significantly elevated to a greater extent than did the other two treatments. Figure 21 illustrates the mean heart rate values during recovery from exercise measured at three times - five, ten and fifteen minutes following the end of exercise.

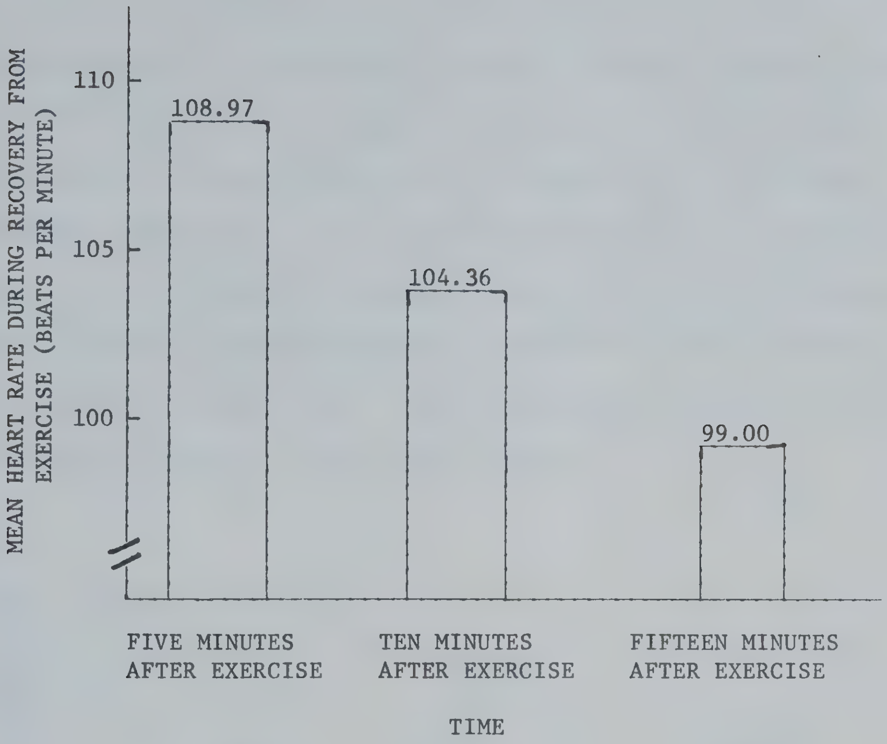


FIGURE 21

MEAN HEART RATE VALUES DURING RECOVERY FROM
EXERCISE FOR THE THREE TIMES

SYSTOLIC BLOOD PRESSURE DURING RECOVERY FROM EXERCISE

Table 34 (Appendix A) summarizes the analysis of variance for systolic blood pressure measured during recovery from exercise. Significant F's were obtained for treatment, session, and time effects. A Scheffé test (Appendix A - Table 35) for treatment effects on systolic blood pressure during recovery from exercise showed that the drug treatment was significantly different from the control and placebo treatments, but there was no significant difference between the control and placebo treatments. Thus, dexedrine caused systolic blood pressure to remain elevated during fifteen minutes of recovery from exercise.

With respect to athletics, it is not physiologically sound for systolic blood pressure to be elevated for a longer period of time than naturally occurs following exercise. Figure 22 illustrates the mean systolic blood pressure values during recovery from exercise for the three treatments. This result is in agreement with the result reported by Golding and Barnard (31) following dexedrine administration. However, Segers, s'Jongers, and Lewillie (62) reported no change in systolic blood pressure during recovery from exercise after being administered dexedrine as compared to the placebo results.

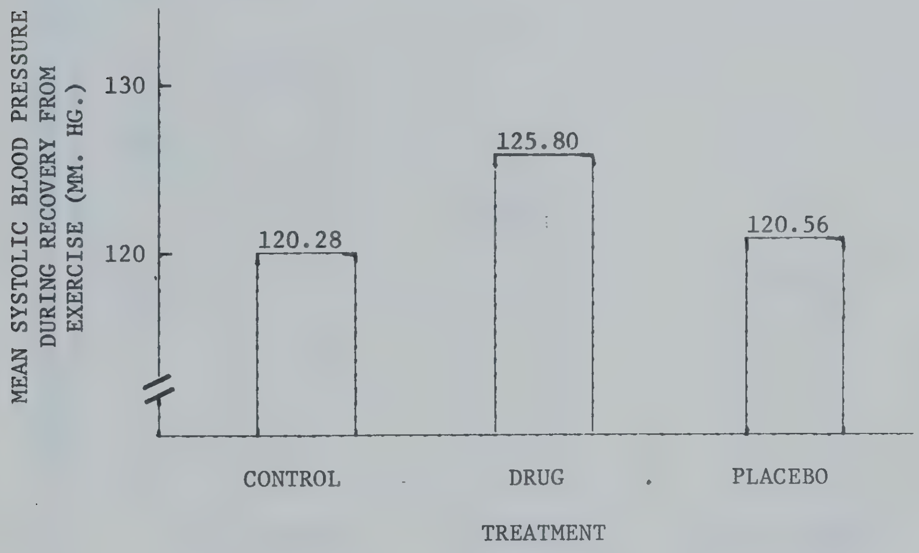


FIGURE 22

MEAN SYSTOLIC BLOOD PRESSURE VALUES DURING RECOVERY
FROM EXERCISE FOR THE THREE TREATMENTS

A Scheffé test (Appendix A - Table 36) for time effects on systolic blood pressure during recovery from exercise, independent of treatment, showed that time one was significantly higher than time two; time one was significantly higher than time three; but there was no

significant difference between time two and time three. Thus, systolic blood pressure decreased significantly, as would be expected, from five minutes of recovery to ten and fifteen minutes of recovery, although the decrease from ten to fifteen minutes was not significant. Figure 23 illustrates the mean systolic blood pressure values during recovery from exercise measured at three times - five, ten, and fifteen minutes following the end of exercise.

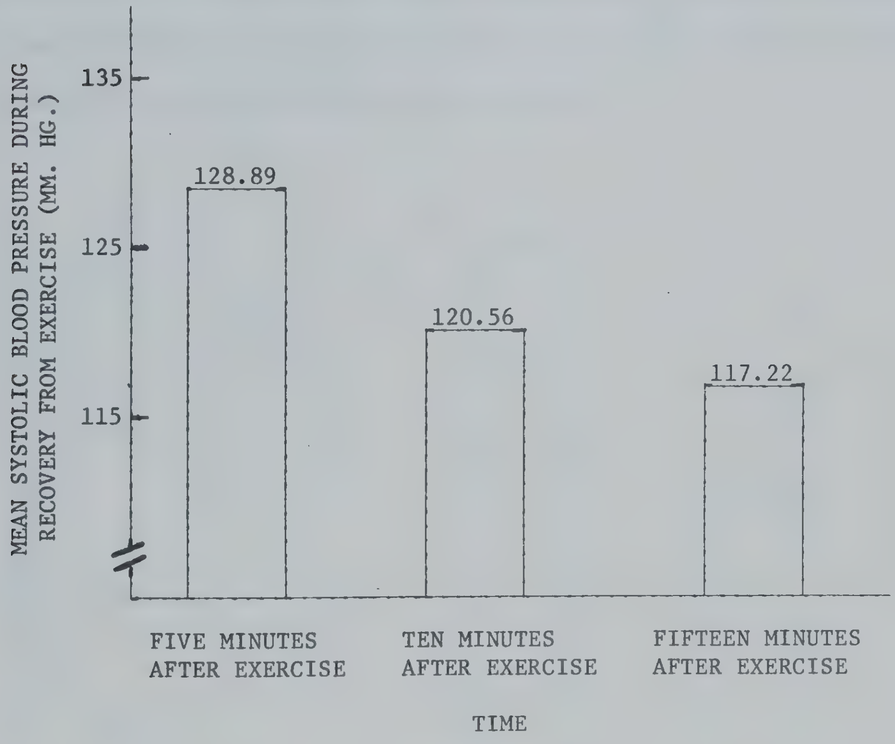


FIGURE 23

MEAN SYSTOLIC BLOOD PRESSURE VALUES DURING RECOVERY FROM EXERCISE FOR THE THREE TIMES

A Scheffé test (Appendix A - Table 37) for session effects on systolic blood pressure during recovery from exercise, independent of treatment, revealed that session one was not significantly different

from session two, but session one was significantly different from session three, and session two was significantly different from session three. The highest mean systolic blood pressure value occurred during session two, and the lowest value occurred during session three. Although significant session effects for systolic blood pressure measured during recovery from exercise were not expected, the lowest value recorded during session three could possibly be attributed to the specificity of training effects from cycling on the bicycle ergometer. Figure 24 illustrates the mean systolic blood pressure values during recovery from exercise for the three sessions.

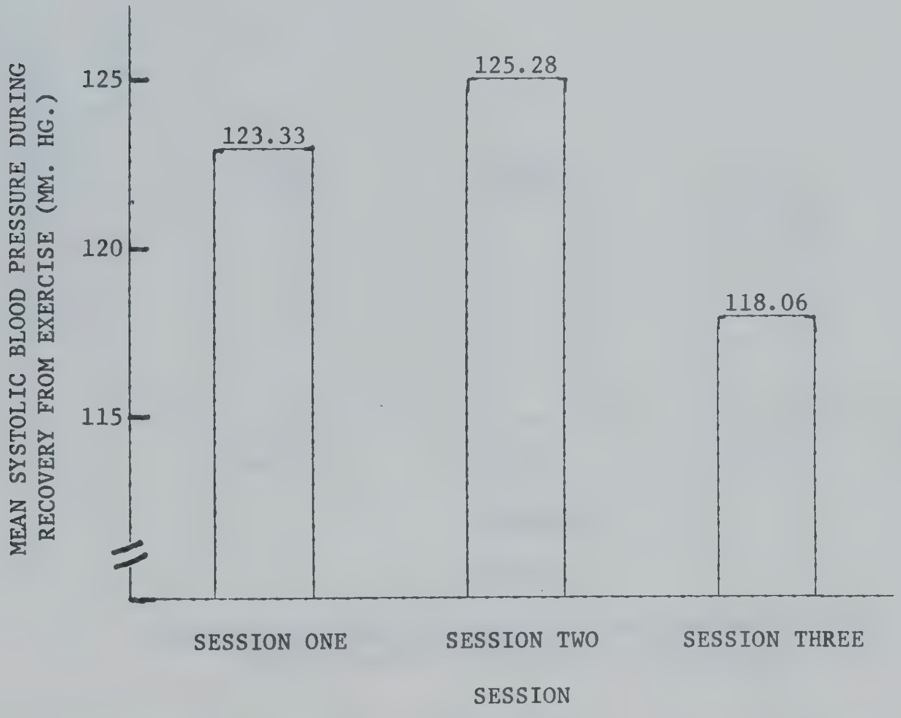


FIGURE 24

MEAN SYSTOLIC BLOOD PRESSURE VALUES DURING RECOVERY FROM EXERCISE FOR THE THREE SESSIONS

DIASTOLIC BLOOD PRESSURE DURING RECOVERY FROM EXERCISE

The analysis of variance for diastolic blood pressure measured during recovery from exercise is presented in Table 38 (Appendix A). There were no significant differences in diastolic blood pressure during recovery from exercise in the analysis used. Thus, dexedrine had no significant effect on diastolic blood pressure during recovery from exercise. This result agrees with the result reported by Segers, s'Jongers, and Lewillie (62) following dexedrine administration. Figure 25 illustrates the mean disatolic blood pressure values during recovery from exercise for the three treatments.

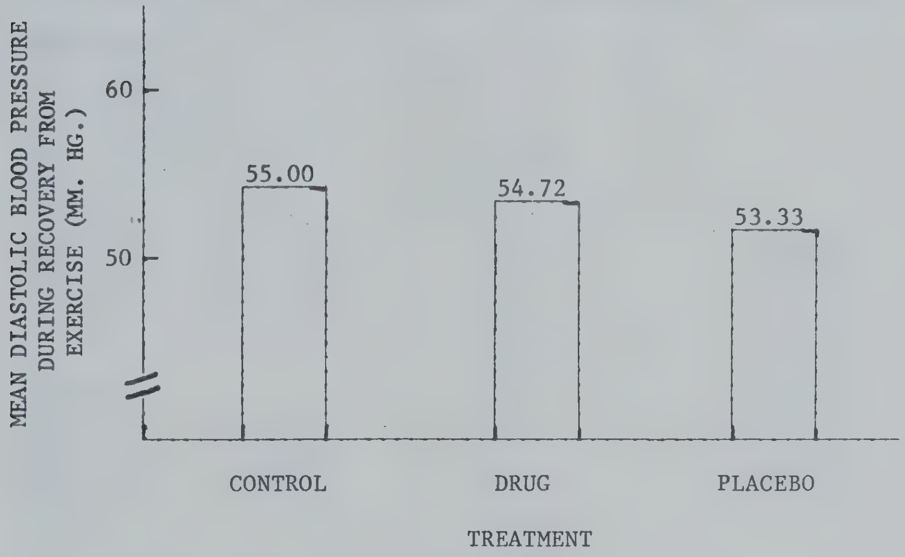


FIGURE 25

MEAN DIASTOLIC BLOOD PRESSURE VALUES DURING RECOVERY FROM EXERCISE FOR THE THREE TREATMENTS

OXYGEN UPTAKE DURING RECOVERY FROM EXERCISE

Table 39 (Appendix A) summarizes the analysis of variance for oxygen uptake during recovery from exercise. Significant F's were

obtained for session, treatment, and time effects. A Scheffé test for treatment effects on oxygen uptake during recovery from exercise revealed that the drug treatment was significantly different from the control treatment; the placebo treatment was significantly different from the control treatment; but the drug and placebo treatments were not significantly different from each other. Segers, s'Jongers, and Lewillie (62) reported no change in oxygen uptake during recovery from exercise following administration of the drug as compared to placebo. Dexedrine had no more effect on oxygen uptake during recovery from exercise than the placebo administered. Figure 26 illustrates the mean oxygen uptake values during recovery from exercise for the three treatments.

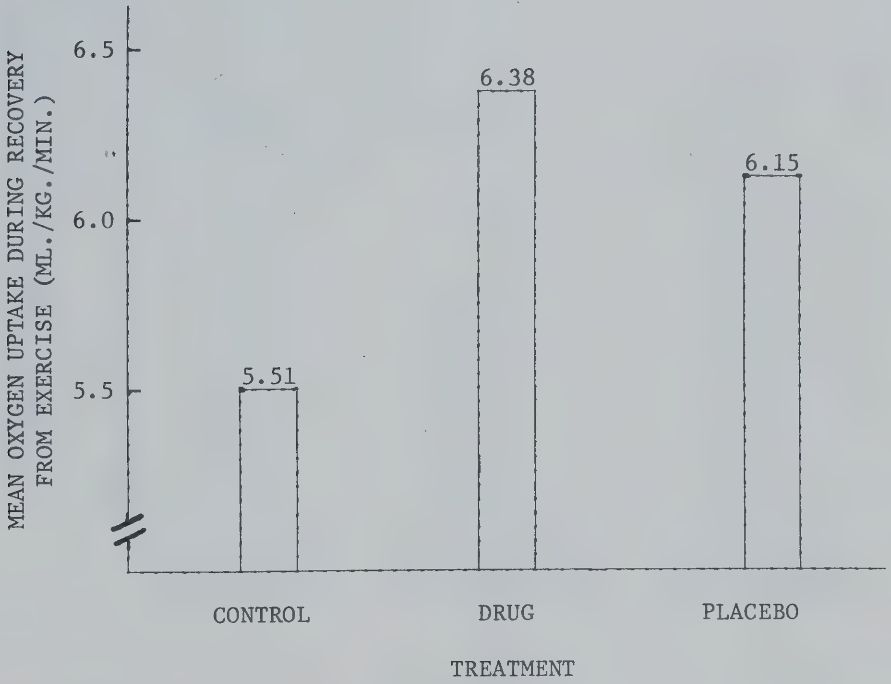


FIGURE 26

MEAN OXYGEN UPTAKE VALUES DURING RECOVERY FROM EXERCISE FOR THE THREE TREATMENTS

A Scheffé test (Appendix A - Table 41) for time effects on oxygen uptake during recovery from exercise, independent of treatment, showed that time one was significantly higher than time two; time one was significantly higher than time three; but there was no significant difference between time two and time three. Oxygen uptake during recovery from exercise decreased, as would be expected, from five to ten and fifteen minutes of recovery but the difference from ten to fifteen minutes was not significant. Figure 27 illustrates the mean oxygen uptake values during recovery from exercise measured at three times - five, ten, and fifteen minutes following the end of exercise.

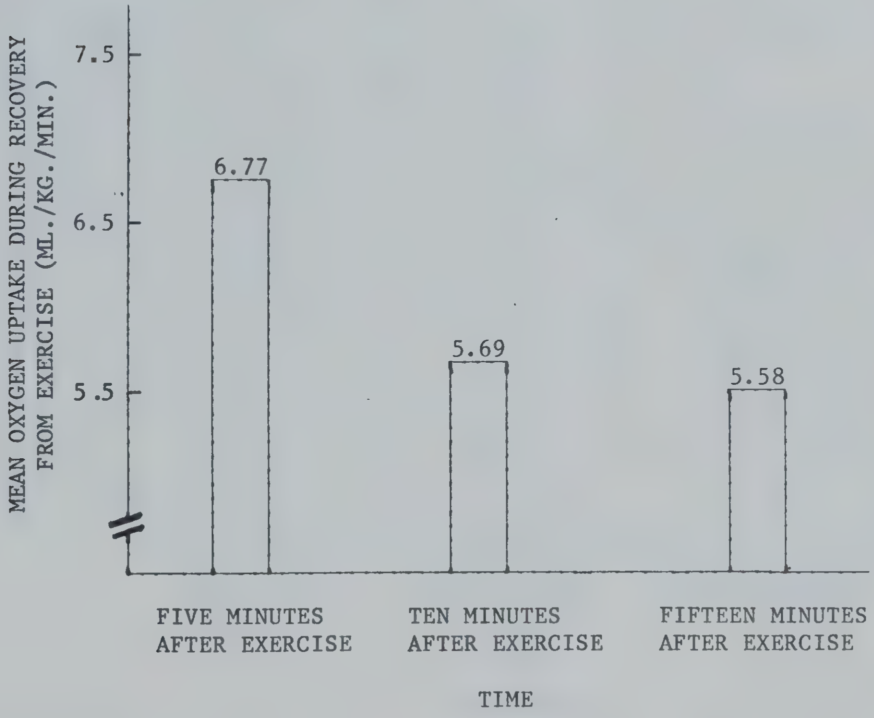


FIGURE 27

MEAN OXYGEN UPTAKE VALUES DURING RECOVERY FROM EXERCISE FOR THE THREE TIMES

A Scheffé test (Appendix A - Table 42) for session effects on oxygen uptake during recovery from exercise, independent of treatment, showed that session one was not significantly different from session two; session one was not significantly different from session three; but session two was significantly higher than session three. Although a significant session effect for oxygen uptake during recovery from exercise was not expected, the significant difference from session two to session three could be attributed to the specificity of training effects from cycling on the bicycle ergometer. Figure 28 illustrates the mean oxygen uptake values during recovery from exercise for the three sessions.

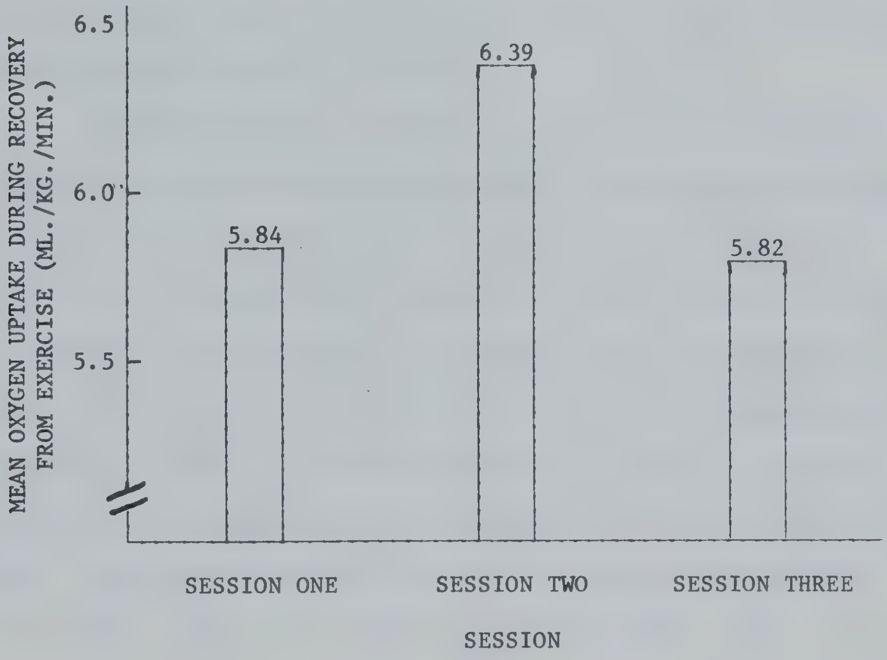


FIGURE 28

MEAN OXYGEN UPTAKE VALUES DURING RECOVERY FROM EXERCISE FOR THE THREE SESSIONS

SUMMARY OF THE PARAMETERS MEASURED DURING RECOVERY FROM EXERCISE

Dextroamphetamine sulfate in the dose of 0.14 mg. per kilogram of body weight had no significant effect on diastolic blood pressure measured during fifteen minutes of recovery following exercise on the bicycle ergometer. Significant drug effects were reported for heart rate, systolic blood pressure, and oxygen uptake measured during fifteen minutes of recovery following exercise on the bicycle ergometer. However, oxygen uptake measured during the drug treatment was significantly different from only the control treatment, and not from the placebo treatment. Thus, heart rate and systolic blood pressure were significantly elevated during recovery from exercise on the bicycle ergometer following administration of the drug as compared to the placebo and control treatments.

The higher values reported for heart rate, systolic blood pressure, and oxygen uptake during recovery from exercise following drug administration lend support to the fact that dexedrine does indeed mask the physiological strain of exertion. This was noticeable especially for the heart rate and systolic blood pressure values. That is, the masking of the physiological sense of fatigue during exercise, and thus the masking of the degree to which the physiological parameters were being taxed was expressed by the significantly higher values reported for heart rate and systolic blood pressure during recovery from exercise following drug administration. Heart rate and systolic blood pressure were elevated to a greater extent during recovery from exercise following drug administration than naturally occurs following exercise. It is not physiologically sound for heart rate and systolic blood pressure to be placed under a greater strain

than would naturally occur.

Although oxygen uptake values for the drug and placebo treatments were not significantly different from each other, the highest oxygen uptake value was reported for the drug treatment. Therefore, it is possible that what was previously stated for heart rate and systolic blood pressure during recovery from exercise could also be true of oxygen uptake during recovery from exercise.

The highest value reported for diastolic blood pressure during recovery from exercise occurred not during the drug treatment but during the placebo treatment. It appears that dexedrine has no effect on diastolic blood pressure during recovery from exercise.

COMPARISONS OF PARAMETERS MEASURED AT REST AND DURING THE FIFTEENTH MINUTE OF RECOVERY FROM EXERCISE

RESTING AND RECOVERY HEART RATE COMPARISONS

The analysis of variance (Appendix A - Table 43) for resting and recovery heart rate comparisons showed significant F's for treatment, time, and treatment by time interaction effects. A Scheffé test (Appendix A - Table 44) for treatment effects on heart rate showed that the drug treatment was significantly greater than both the placebo and control treatments, but there was no significant difference between the control and placebo treatments. Figure 29 illustrates the mean resting and recovery heart rate values for the three treatments.

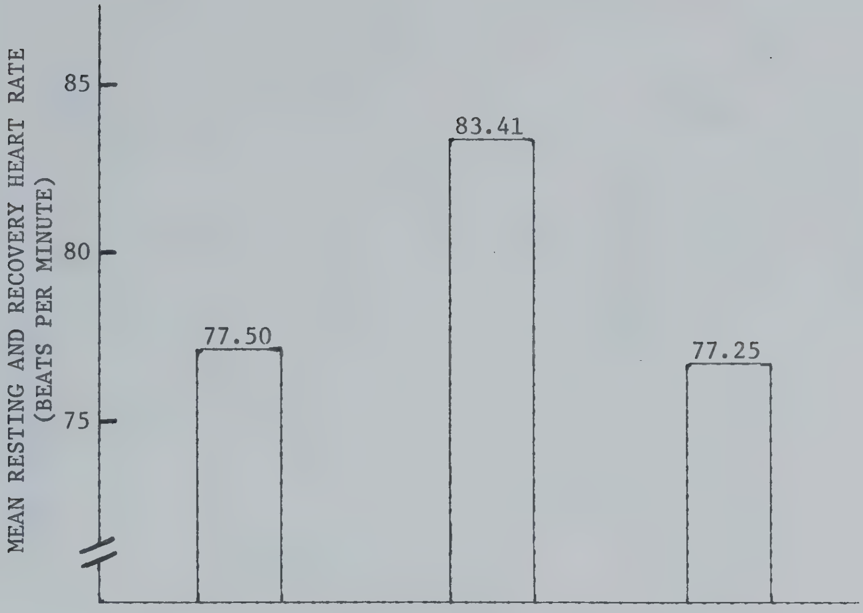


FIGURE 29

MEAN RESTING AND RECOVERY HEART RATE VALUES FOR THE THREE TREATMENTS

The mean recovery heart rate value at the fifteen minute of recovery following exercise was significantly higher than the mean resting heart rate value, independent of treatment. Thus, heart rate was still significantly elevated fifteen minutes following the end of exercise as compared to heart rate prior to exercising. Figure 30 illustrates the mean heart rate values for rest and recovery, independent of treatment.

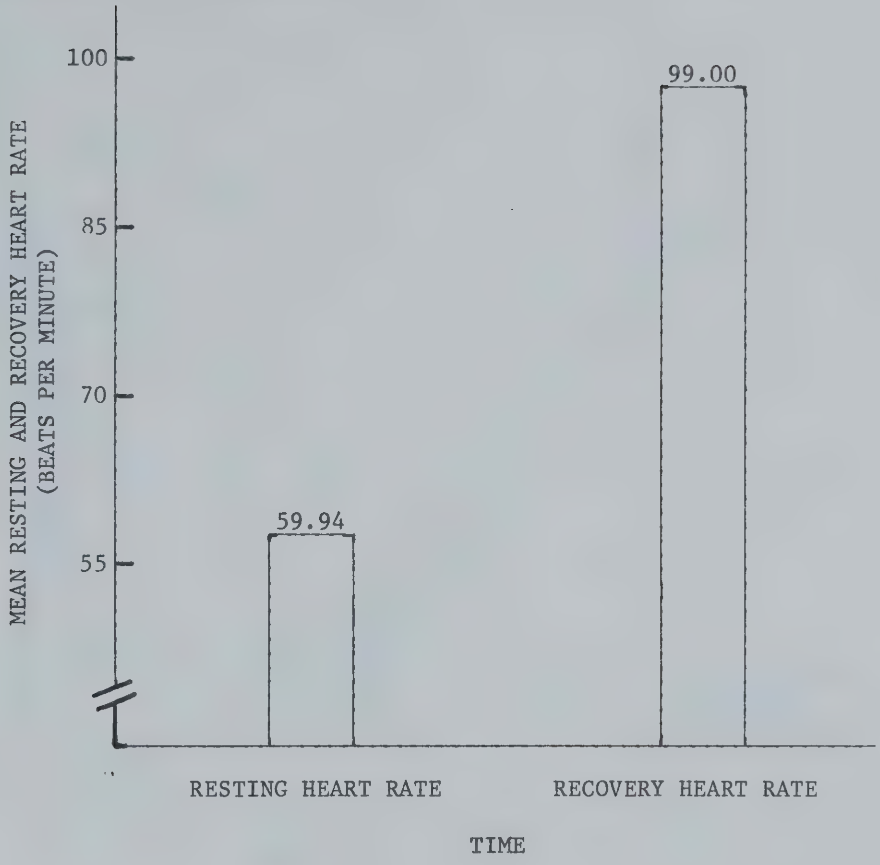
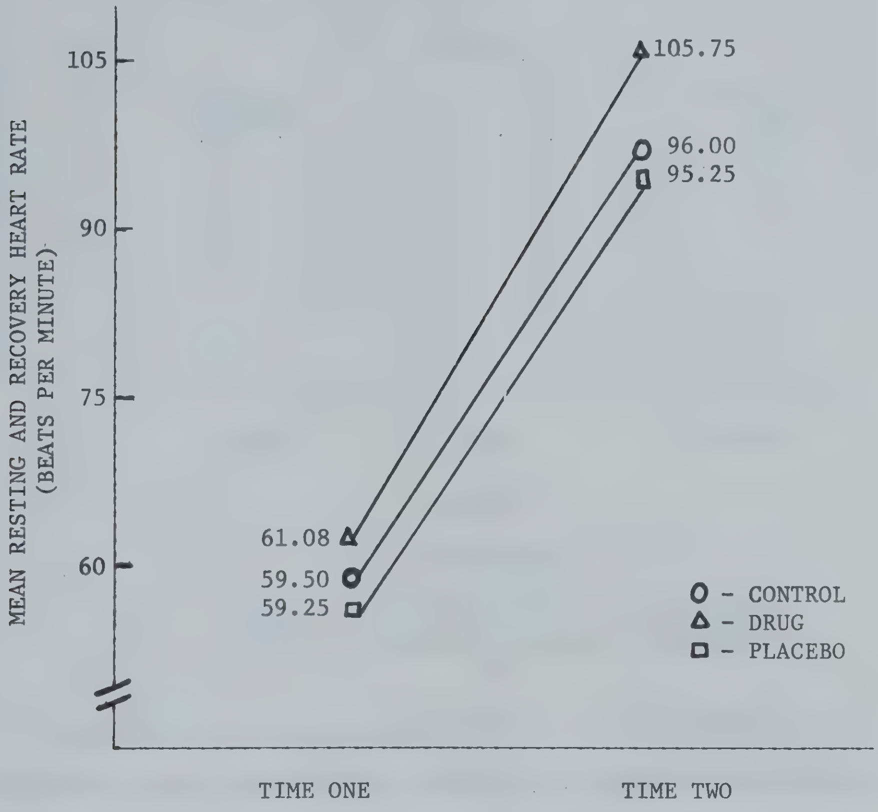


FIGURE 30

MEAN RESTING AND RECOVERY HEART RATE VALUES
INDEPENDENT OF TREATMENT

Table 45 (Appendix A) shows the significant treatment x time interaction effects using a Scheffé test. For the Scheffé test, 0.10 was used as the level of significance. Figure 31 shows the mean resting and recovery heart rate values for the treatment x time interaction effects. The graph illustrates a significant ordinal interaction of treatment by time effects. Although the main effects of treatment and time were both significant, the interaction of treatment by time shows that the drug treatment caused higher heart rates at both rest and recovery as

compared to the placebo and control treatments.



TIME

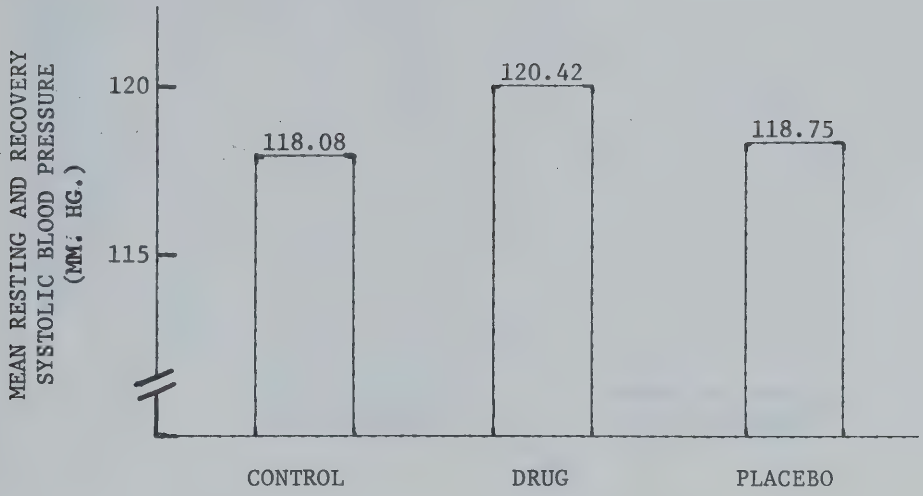
FIGURE 31

MEAN RESTING AND RECOVERY HEART RATE VALUES
FOR TREATMENT X TIME INTERACTION

RESTING AND RECOVERY SYSTOLIC BLOOD PRESSURE COMPARISONS

The analysis of variance for resting and recovery systolic blood pressure comparisons is summarized in Table 46 (Appendix A). No significant differences in mean resting and recovery systolic blood pressure occurred among the three treatments. Figure 32 illustrates the mean resting and recovery systolic blood pressure values for the three

treatments.



TREATMENT

FIGURE 32

MEAN RESTING AND RECOVERY SYSTOLIC BLOOD PRESSURE VALUES FOR THE THREE TREATMENTS

Significant F's were obtained for time and session effects. Mean systolic blood pressure was significantly higher at rest than after fifteen minutes of recovery from exercise. The systolic blood pressure values obtained at rest could have been raised due to factors existing prior to beginning exercise (for example, pretension). Thus, the mean resting systolic blood pressure obtained may not be truly reflective of the resting value. Figure 33 illustrates the mean resting and recovery systolic blood pressure values, independent of treatment.

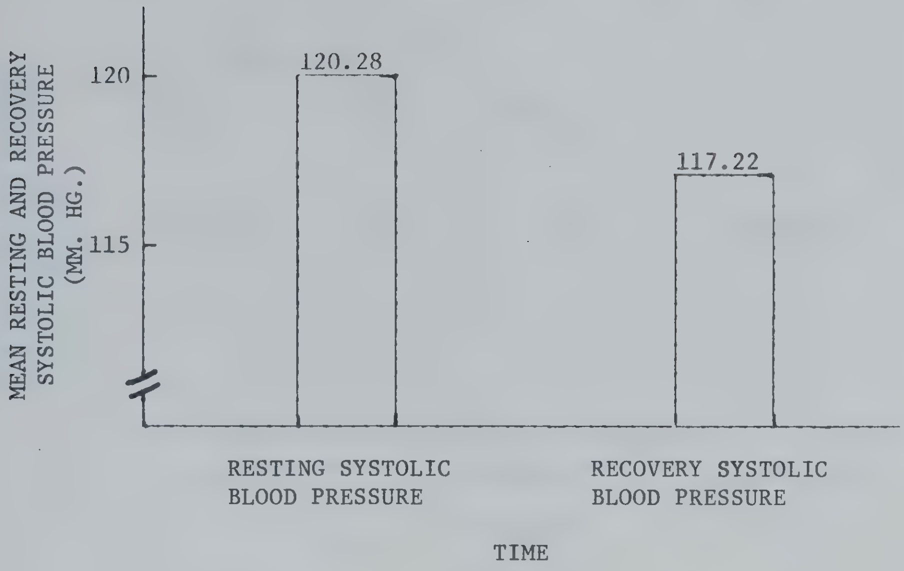


FIGURE 33

MEAN RESTING AND RECOVERY SYSTOLIC BLOOD
PRESSURE VALUES INDEPENDENT OF TREATMENT

A Scheffé test (Appendix A - Table 47) for session effects on systolic blood pressure showed that session one was significantly higher than session three, but there were no significant differences from session one to session two, or from session two to session three. Although a significant difference in systolic blood pressure from session one to session three was not expected, the specificity of training effects from cycling on the bicycle ergometer could have attributed to the significantly lower mean systolic blood pressure value for rest and recovery during session three as compared to session one. Figure 34 illustrates the mean resting and recovery systolic blood pressure values for the three sessions, independent of treatment.

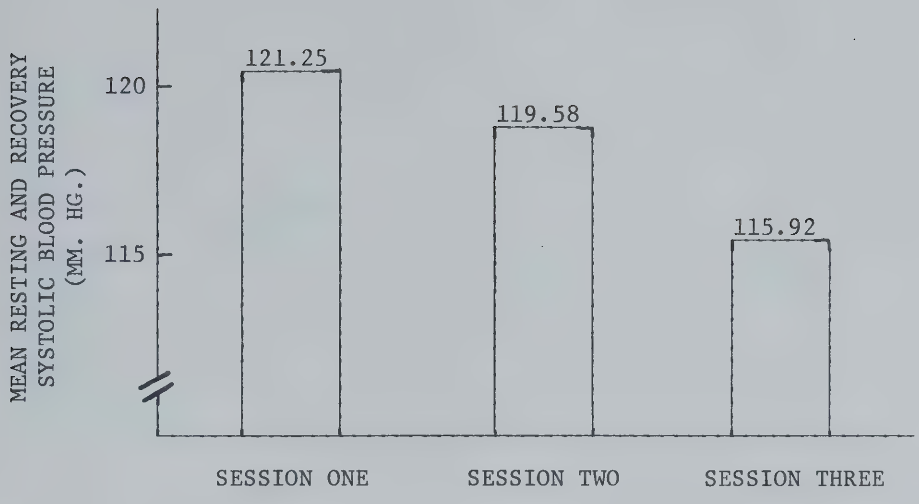
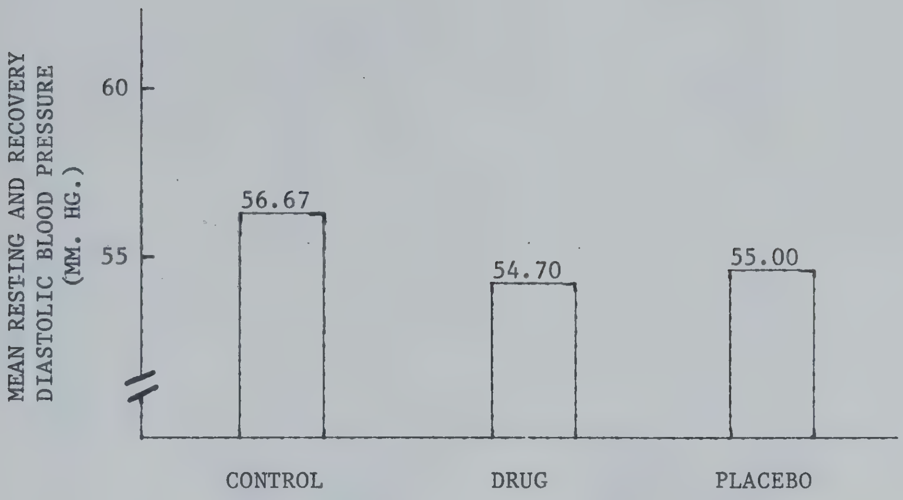


FIGURE 34

MEAN RESTING AND RECOVERY SYSTOLIC BLOOD PRESSURE VALUES FOR THE THREE SESSIONS

RESTING AND RECOVERY DIASTOLIC BLOOD PRESSURE COMPARISONS

The analysis of variance for resting and recovery diastolic blood pressure is summarized in Table 48 (Appendix A). No significant differences in mean resting and recovery diastolic blood pressure occurred among the three treatments. Figure 35 illustrates the mean resting and recovery diastolic blood pressure values for the three treatments.



TREATMENT

FIGURE 35

MEAN RESTING AND RECOVERY DIASTOLIC BLOOD PRESSURE VALUES FOR THE THREE TREATMENTS

Significant F's were obtained for session and time effects. Mean diastolic blood pressure was significantly higher at rest than after fifteen minutes of recovery following exercise. Factors existing prior to exercise (for example, pretension) could have attributed to the higher mean diastolic blood pressure value obtained at rest. Thus, the mean resting diastolic blood pressure value obtained may not be truly indicative of the resting value. Figure 36 illustrates the mean resting and recovery diastolic blood pressure values, independent of treatment.

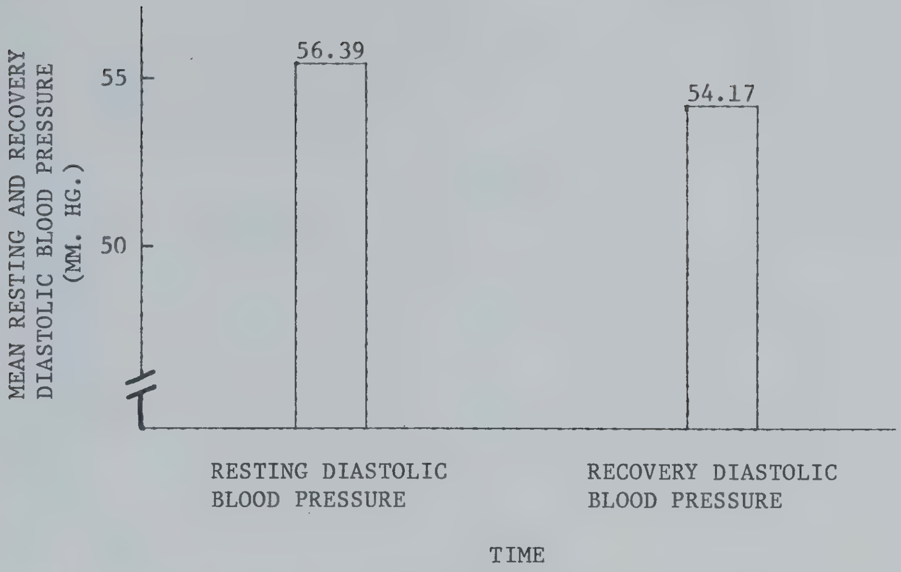


FIGURE 36

MEAN RESTING AND RECOVERY DIASTOLIC BLOOD PRESSURE VALUES INDEPENDENT OF TREATMENT

A Scheffé test (Appendix A - Table 49) for session effects on diastolic blood pressure showed that session two was significantly higher than session three, but there were no significant differences from session one to session two or from session one to session three. Although a significant difference in diastolic blood pressure from session two to session three was not expected, it is possible that the specificity of training effects from cycling on the bicycle ergometer could have attributed to the significantly higher diastolic blood pressure value obtained during session two compared to session three. Figure 37 illustrates the mean resting and recovery diastolic blood pressure values for the three sessions, independent of treatment.

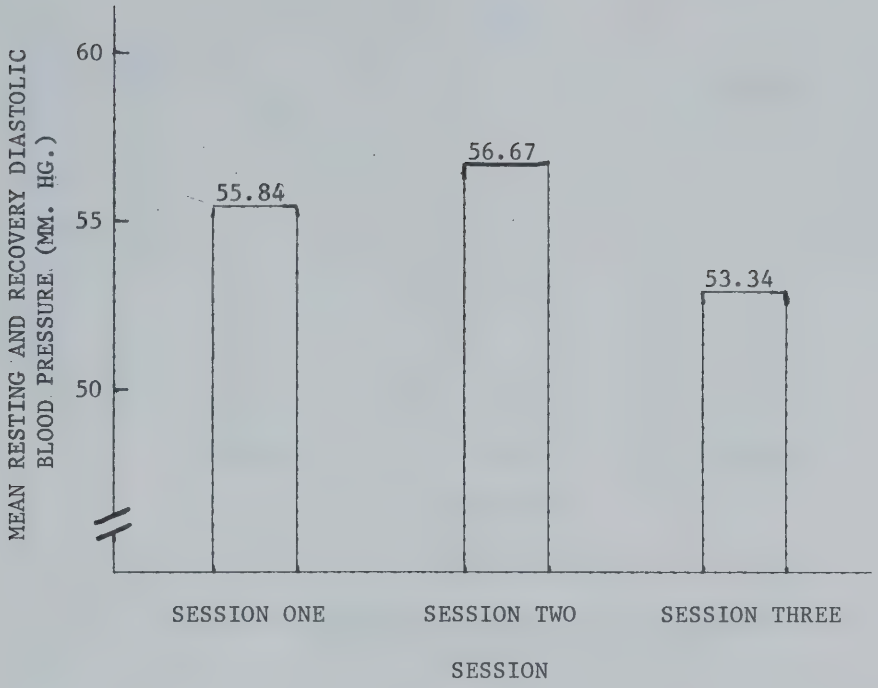


FIGURE 37

MEAN RESTING AND RECOVERY DIASTOLIC BLOOD PRESSURE VALUES FOR THE THREE SESSIONS

RESTING AND RECOVERY OXYGEN UPTAKE COMPARISONS

Table 50 (Appendix A) summarizes the analysis of variance for resting and recovery oxygen uptake. No significant differences occurred in mean resting and recovery oxygen uptake values among any of the three treatments. Figure 38 illustrates the mean resting and recovery oxygen uptake values for the three treatments.

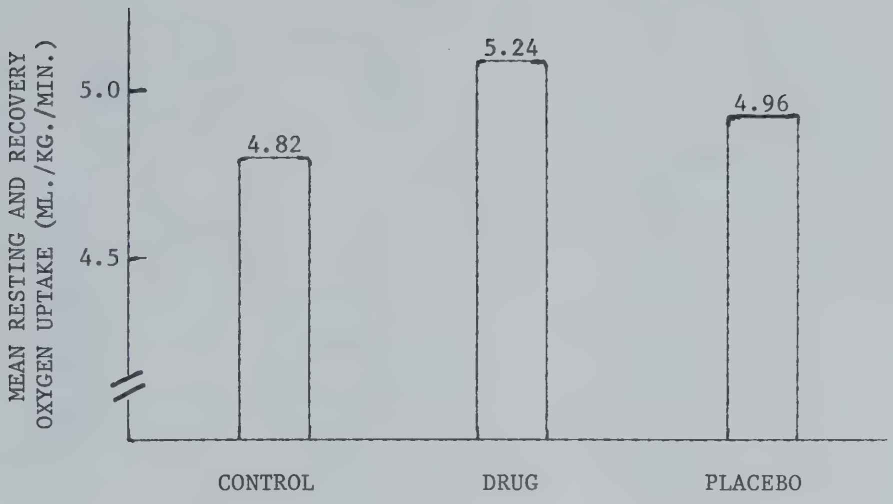


FIGURE 38

MEAN RESTING AND RECOVERY OXYGEN UPTAKE VALUES FOR THE THREE TREATMENTS

A significant F was reported for time effect. Oxygen uptake was significantly higher fifteen minutes following the end of exercise than at rest. Thus, oxygen uptake, independent of treatment, was significantly elevated fifteen minutes following the end of exercise as compared to the mean resting oxygen uptake value obtained prior to exercising. Thus, the oxygen debt accumulated during exercise was not repayed following fifteen minutes of recovery from exercise on the bicycle ergometer. Figure 39 illustrates the mean resting and recovery oxygen uptake values, independent of treatment.

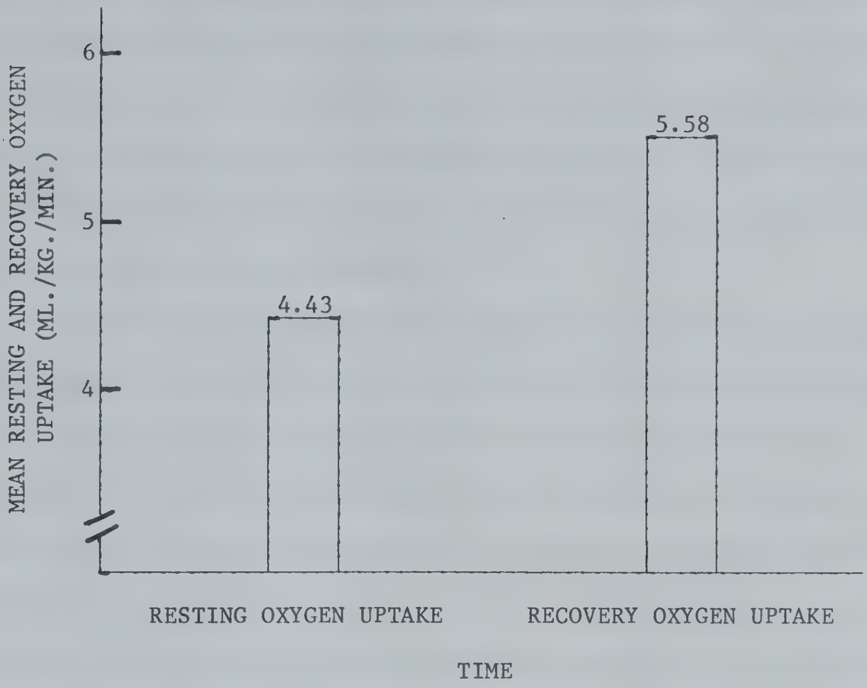


FIGURE 39

MEAN RESTING AND RECOVERY OXYGEN UPTAKE
VALUES INDEPENDENT OF TREATMENT

SUMMARY OF THE COMPARISONS OF PARAMETERS MEASURED AT REST AND DURING THE FIFTEENTH MINUTE OF RECOVERY FROM EXERCISE

Dextroamphetamine sulfate in the dose of 0.14 mg. per kilogram of body weight significantly affected mean resting and recovery heart rate. Heart rate was still significantly elevated following fifteen minutes of recovery from exercise on the bicycle ergometer as compared to resting heart rate. Also heart rate was significantly elevated to a greater extent during recovery from exercise following drug administration than naturally occurs following exercise. Mean resting and recovery systolic blood pressure, diastolic blood pressure, and oxygen uptake values were not significantly affected by the drug.

Independent of treatment, systolic and diastolic blood pressures were significantly higher at rest than after fifteen minutes of recovery following exercise on the bicycle ergometer. However, independent of treatment, oxygen uptake was significantly elevated following fifteen minutes of recovery from exercise as compared to oxygen uptake prior to exercising on the bicycle ergometer.

The masking of physiological fatigue by dexedrine was supported by the significant resting and recovery heart rate value during drug administration. Although after fifteen minutes of recovery from exercise heart rate was still significantly elevated as compared to mean resting heart rate, independent of treatment, the drug caused the heart rate to remain significantly elevated to a greater extent than the placebo and control treatments. The subjects during exercise were therefore placing themselves under a greater physiological strain with respect to heart rate than would have naturally occurred by exercise. Independent of treatment, fifteen minutes of recovery from exercise on the bicycle ergometer were not sufficient for heart rate to return to resting level. However, the drug would apparently delay even more the return of heart rate to the resting level. It would appear that this could be a potentially dangerous situation for the athlete. It is not logical to keep the heart rate elevated to a greater level and for a longer period of time than occurs naturally through exercise.

The highest value reported for mean resting and recovery systolic blood pressure was during the drug treatment although this value was not significantly different from the control and placebo treatments. Independent of treatment, fifteen minutes of recovery from exercise was sufficient for systolic blood pressure to return to

resting level. This would be expected as systolic blood pressure drops rapidly after the cessation of exercise.

The highest value reported for mean resting and recovery diastolic blood pressure occurred not during the drug treatment but during the control treatment. The drug appears not to have any effect on diastolic blood pressure.

The highest value reported for mean resting and recovery oxygen uptake occurred during the drug treatment although this value was not significantly different from the control and placebo treatments. Independent of treatment, fifteen minutes of recovery from exercise was not sufficient time for oxygen uptake to return to resting level.

SUMMARY OF THE PARAMETERS MEASURED AT REST, DURING EXERCISE AND DURING RECOVERY FROM EXERCISE

The following summary was included as a synopsis of the summaries previously presented in the chapter on parameters measured at rest, during exercise, and during recovery from exercise. This summary will serve to assimilate some of the more salient points of the previous summaries.

Dextroamphetamine sulfate in the dose of 0.14 mg. per kilogram of body weight had no significant effects on heart rate, systolic or diastolic blood pressures, or oxygen uptake measured at rest; systolic or diastolic blood pressures, oxygen uptake, or ratings of perceived exertion measured at specific time intervals during exercise; or diastolic blood pressure measured during recovery from exercise. The drug administered had no significant effect on endurance performance

time on the bicycle ergometer. Significant drug effects were reported for heart rate measured during exercise and during recovery from exercise, and systolic blood pressure measured during recovery from exercise. Independent of treatment, heart rate was still significantly elevated following fifteen minutes of recovery from exercise as compared to resting heart rate. However, the drug caused the heart rate to remain significantly elevated to a greater extent than the placebo and control treatments. Oxygen uptake measured during recovery from exercise was significantly different between the drug and control treatments but not between the drug and placebo treatments. Independent of treatment, oxygen uptake was significantly elevated following fifteen minutes of recovery from exercise as compared to oxygen uptake measured prior to exercising on the bicycle ergometer.

The results reported for the parameters measured at rest could be expected as dexedrine exerts weak peripheral sympathomimetic effects (17, 19, 29, 33, 34, 45, 47). However, a larger drug dose than 0.14 mg. per kilogram of body weight could possibly cause significant effects on the physiological parameters measured at rest.

The dominant action of dexedrine as a central nervous system stimulant is the masking of the physiological sense of fatigue (21, 30, 33, 44, 45, 47, 52, 53). Thus, the potential exists for dexedrine to affect physical performance and physiological parameters, to a greater extent than would naturally occur from exercise, through a distortion of one's perception of exertion. It is apparent that dexedrine administration could be a potentially dangerous situation for the athlete as he may be strained beyond his natural physiological limitations. That is, although the sense of fatigue may be masked or

distorted, to varying degrees, the physiological fatigue is not abolished.

The evidence that dexedrine did indeed mask the sense of fatigue during exercise was most noticeable in significant results reported for heart rate during exercise and during recovery from exercise following drug administration. During exercise and during recovery from exercise, heart rate was elevated to a greater extent than would naturally occur from exercise. Thus, the heart was being physiologically taxed to a greater extent than naturally occurs from exercise. It is not physiologically sound for the heart to be placed under a greater physiological strain than is either natural or necessary.

Although significant results were not reported for most of the other parameters measured, the tendency existed from the results of some of the other parameters to lend support to the masking of the sense of fatigue by dexedrine. The highest value reported for systolic blood pressure during exercise and the lowest ratings of perceived exertion for the same work load occurred during drug administration. Although the subjects were being physiologically taxed with respect to heart rate and systolic blood pressure during exercise to a greater extent under the drug treatment, the longest cycling time occurred during drug administration. Systolic blood pressure measured during fifteen minutes of recovery from exercise was significantly elevated following drug administration as compared to placebo and control treatments. However, systolic blood pressure was not higher after fifteen minutes of recovery from exercise than it was at rest. It appears that the drug kept systolic blood pressure elevated for ten

minutes following the end of exercise, but fifteen minutes was sufficient time for systolic blood pressure to return to resting level.

Results of a different nature were reported for diastolic blood pressure and oxygen uptake measured during exercise and during recovery from exercise. It appears that dexedrine exerts no effect on diastolic blood pressure either during exercise or during recovery from exercise. The lowest oxygen uptake value measured during exercise occurred during the drug treatment. During recovery from exercise, the highest value for oxygen uptake was during the drug treatment, but it was only significantly different from the control treatment and not from the placebo treatment. It appears that dexedrine did not have a consistent effect on oxygen uptake during exercise and during recovery from exercise.

The preceding discussion illustrates the fact that the tendency existed for dexedrine to mask or distort, to varying degrees, the perception of exertion and in doing so affect physical performance and physiological parameters. If the dose of the drug used was greater, it is possible that the masking of fatigue would have been more explicit, and thus, the physical performance and physiological parameters measured may have been significantly affected.

COMPARISON OF PREDICTED AND ACTUAL HEART RATES

For the three testing sessions, the subjects cycled at predetermined constant work loads at 60 revolutions per minute. Minute by minute pedal revolutions were recorded for all subjects. At no time was the average number of revolutions per minute below 50. Minute by minute heart rates for each subject were also recorded.

Table 53 (Appendix I) lists the heart rates for the twelve subjects corresponding to 90% of the maximum heart rates attained during the preliminary test, and the heart rates recorded at the tenth minute of exercise for the control session. As can be seen from Table 53, the two heart rates for all but one subject are within ± 12 beats; and for the one subject there is a fourteen beat difference. The results of a t-test (Appendix A - Table 51) showed no significant difference in the means for these two sets of heart rates. Thus, what was predicted as the heart rates from the preliminary testing session corresponded to the actual heart rates during the control testing session. Thus, the subjects were working at a heart rate corresponding to 90% of their maximum heart rates attained during the preliminary testing session on the progressive work load test. For comparison of predicted and actual heart rates, heart rate at the tenth minute of exercise during the control session was chosen as the exercise on the bicycle ergometer was of a relatively long duration, and ten minutes was felt to be a good time for indication of the levelling off of the heart rate at the predicted level. Only the heart rates during the control session could be compared with the predicted heart rates as the drug and placebo sessions contribute effects independent of exercise.

COMPARISON OF END OF EXERCISE HEART RATES

As each subject decided, for all testing sessions, the end point of exercise, the end of exercise heart rates was used as an indication of the degree to which the subjects exercised to fatigue. Only the end of exercise heart rates from the preliminary testing session and from the control session can be compared. The results from

the drug and placebo sessions are confounded with other influencing factors independent of exercise. Table 7 lists the maximum heart rates attained during the preliminary testing session, and the end of exercise heart rates attained during the control session. The two heart rates for eleven out of the twelve subjects were within nine beats of each other. In fact, identical heart rates were recorded for four of the subjects, three beats difference was recorded for one subject, six beats difference was recorded for one subject, seven beats difference was recorded for three subjects, eight beats difference was recorded for one subject, and nine beats difference was recorded for one subject. One subject had a difference of thirteen beats between the two heart rates - the end of exercise control session heart rate was thirteen beats lower than the end of exercise preliminary session heart rate. It appears that eleven out of the twelve subjects worked to similar levels of individual fatigue for each testing session. One subject possibly stopped before he actually had to. However, as the control session was the final testing session for this particular subject, the specificity of training effects from cycling on the bicycle ergometer from the preliminary session to the final session could have attributed to the difference in the heart rates observed.

TABLE 7

END OF EXERCISE HEART RATES (BEATS PER MINUTE)

Subject Number	Preliminary Session	Control Session
1	195	195
2	173	173
3	180	180
4	180	173
5	184	187
6	195	187
7	187	180
8	180	180
9	167	161
10	173	164
11	180	167
12	187	180

COMMENT ON THE DRUG ADMINISTERED

It was apparent to the investigator only when two of the twelve subjects had been administered the drug. The general aura around them indicated that they had been administered the drug. Their attentiveness and interest for the task, that is, cycling at the constant work load, seemed to increase. For both subjects, their talkativeness to the investigator increased. It is interesting to note that both subjects went backwards on the rating scale of perceived exertion between certain time intervals during exercise. That is, the work appeared to become

easier as the time they were cycling became longer. It appears that at times during exercise the drug distorted the subjects' perceptions of the actual work they were doing. No other effects were noticed with any of the other subjects.

The subjects were asked to state at the end of the two testing sessions when they had been administered either the placebo or the drug, whether they thought they had received the placebo or the drug. Seven of the twelve subjects said they had received the placebo when in fact they had received the drug. Five of the subjects correctly stated when they had received the drug. However, the answers from eleven of the twelve subjects were nothing more than guesses. One subject by having previous experience with a similar drug knew when he had been given the drug.

RESULTS OF URINE ANALYSIS

Studies dealing with the effects of drugs on physiological, psychological, or physical performance parameters of humans very rarely include any method of determining if the drug being studied was, in fact, absorbed. It is always assumed that the drug being studied was absorbed. The gas-liquid chromatography used in this study for estimation of dextroamphetamine sulfate in urine provides more than pure assumption that the drug was absorbed.

Table 8 provides the results of the analysis for estimating the amount of dexedrine in the urine. Figure 40 (Appendix H) illustrates a typical chromatograph resulting from the gas-liquid chromatography. Table 74 (Appendix K) provides the data for the volume of urine produced and the pH of the urine for each subject. As can be

observed from Table 8, measurable levels of dexedrine were found in the urine of four of the subjects, detectable levels in the urine of three of the subjects, and dexedrine was not detectable in the urine of four of the subjects. Urine analysis was not done for one subject. The fact that dexedrine was not detectable in the urine of four of the subjects means that the drug was not detectable with the method used; it does not mean that the dexedrine was not present. Also, as the assay for dexedrine was set up and calibrated in less than forty-eight hours, the results may be subject to more experimental error than usual. However, one can still be sure that dexedrine was present, but the estimates of the amount could be in error by ± 20%. However, the primary purpose was to determine if any of the drug had been absorbed and not the quantity of the drug abosrbed.

TABLE 8

ANALYSIS OF DEXEDRINE IN URINE

Subject Number	Dexedrine Area	Standard Area	Ratio	Dexedrine µg/5ml.	Total Dexedrine (µg)
1	Trace	--	c. 0.01	1.0	16.00
2	Trace	--	c. 0.01	1.0	10.00
3	Not Detectable	--	--	<1.0	
4	27.5	784	0.04	1.3	14.04
5	Not Detectable	--	--	<1.0	
6	125	810.9	0.15	2.0	28.00
7	39	570	0.07	1.6	27.52
8	Not Detectable	--	--	<1.0	
9	16.5	652.8	0.03	1.1	27.28
10	Trace	--	c. 0.01	<1.0	18.40
11	Not Detectable	--	--	1.0	
12	Incomplete				

The excretion of dexedrine is largely dependent on urinary pH. In an acidic urine larger quantities of dexedrine are excreted than in an alkaline urine. As urinary pH becomes more alkaline, the ratio of unionized to ionized amphetamine in the intraluminar fluid of the tubules increases relative to that in the plasma. This results in more of the drug being reabsorbed and thus reducing the excretion rate. At a pH of 6.0 - 7.0 renal clearance is lower, and there is substantial reabsorption of dexedrine (71). The urinary pH's of the subjects tested in this study ranged from 5.8 to 7.0. With this in mind, it was not surprising that dexedrine was not detectable in all of the subjects. Not controlling for urinary pH, and still observing dexedrine levels in seven out of the eleven subjects is noteworthy. The urinary pH's of the subjects in whom dexedrine was not detectable were 6.0, 6.2, 6.7, and 7.0. These pH values, especially 6.7 and 7.0, could possibly explain the reason for not detecting dexedrine with the method used.

Although it is important to know if the drug being studied was absorbed, it becomes of more value to know precisely how much of the drug was absorbed to have potential effect during the time when the parameters studied were tested. It then becomes essential to know the blood concentration of the drug being studied. Sophisticated studies dealing with drugs should include as standard procedures the taking of urine samples and blood samples for precision in determining the absorption of the drug being studied. Results obtained on the parameters being investigated can be more meaningfully discussed if exact amounts of drug absorption and potential effectiveness of the drug being studied are known.

CHAPTER V

SUMMARY AND CONCLUSIONS

SUMMARY

The purpose of this study was to investigate the effects of dextroamphetamine sulfate on selected physiological, psychological, and physical performance parameters of male athletes in the noncompetitive season. A sample of twelve volunteer male athletes ranging in age from 18 to 33 years participated in the study. Each subject received 0.14 mg. per kilogram of body weight of dextroamphetamine sulfate in a solution of eight ounces of orange juice.

All subjects completed a preliminary session to determine maximum heart rates and corresponding work loads on a progressively increased work load test on the bicycle ergometer. From the results of this test, work loads corresponding to 90% of the subjects' maximum heart rates attained during the test were determined. These work loads were used for the next three testing sessions.

For the three testing sessions, each subject completed the test protocol once without taking either dextroamphetamine sulfate or the placebo, once after being administered the drug, and once after being administered the placebo. The order in which the subjects received the three treatments was determined by the standard form of a 3 x 3 Latin square design. Both the drug and the placebo were administered double blind one-half hour prior to exercise.

Resting measurements of heart rate, systolic and diastolic blood pressures, and oxygen uptake were taken one-half hour after reporting

to the laboratory. Endurance performance time on the bicycle ergometer at the predetermined constant work loads was measured. Heart rate, systolic and diastolic blood pressures, oxygen uptake, and ratings of perceived exertion were measured at specific time intervals during exercise. Recovery measurements of heart rate, systolic and diastolic blood pressures, and oxygen uptake were taken five, ten, and fifteen minutes following the end of exercise.

Dextroamphetamine sulfate in the dose of 0.14 mg. per kilogram of body weight had no significant effects on heart rate, systolic or diastolic blood pressures, or oxygen uptake measured at rest. The drug administered had no significant effect on endurance performance time on the bicycle ergometer. Systolic and diastolic blood pressures, oxygen uptake, and ratings of perceived exertion measured during exercise were not significantly affected by the administration of the drug. Heart rate was the only parameter measured during exercise that was significantly affected by the administration of dextroamphetamine sulfate. Diastolic blood pressure measured during recovery from exercise was not significantly affected by the administration of the drug. Significant drug effects were reported for both heart rate and systolic blood pressure measured during fifteen minutes of recovery from exercise. Independent of treatment, heart rate was still significantly elevated following fifteen minutes of recovery from exercise as compared to resting heart rate. However, the drug caused heart rate to remain significantly elevated to a greater extent than the placebo and control treatments. Oxygen uptake measured during recovery from exercise was significantly different between the drug and control treatments but not between the drug and placebo treatments.

Independent of treatment, oxygen uptake was significantly elevated following fifteen minutes of recovery from exercise as compared to oxygen uptake measured prior to exercising on the bicycle ergometer.

CONCLUSIONS

The following conclusions are made with respect to the hypotheses originally drawn:

1) There was no significant difference in heart rate at rest one-half hour after being administered 0.14 mg. per kilogram of body weight of dextroamphetamine sulfate.
2) There was no significant difference in systolic blood pressure at rest one-half hour after being administered 0.14 mg. per kilogram of body weight of dextroamphetamine sulfate.
3) There was no significant difference in diastolic blood pressure at at rest one-half hour after being administered 0.14 mg. per kilogram of body weight of dextroamphetamine sulfate.
4) There was no significant difference in oxygen uptake at rest one-half hour after being administered 0.14 mg. per kilogram of body weight of dextroamphetamine sulfate.
5) There was a significant difference in heart rate during exercise after being administered 0.14 mg. per kilogram of body weight of dextroamphetamine sulfate.
6) There was no significant difference in systolic blood pressure during exercise after being administered 0.14 mg. per kilogram of body weight of dextroamphetamine sulfate.

7) There was no significant difference in diastolic blood pressure during exercise after being administered 0.14 mg. per kilogram of body weight of dextroamphetamine sulfate.
8) There was no significant difference in oxygen uptake during exercise after being administered 0.14 mg. per kilogram of body weight of dextroamphetamine sulfate.
9) There was a significant difference in heart rate during recovery from exercise after being administered 0.14 mg. per kilogram of body weight of dextroamphetamine sulfate.
10) There was a significant difference in systolic blood pressure during recovery from exercise after being administered 0.14 mg. per kilogram of body weight of dextroamphetamine sulfate.
11) There was no significant difference in diastolic blood pressure during recovery from exercise after being administered 0.14 mg. per kilogram of body weight of dextroamphetamine sulfate.
12) There was a significant difference in oxygen uptake during recovery from exercise after being administered 0.14 mg. per kilogram of body weight of dextroamphetamine sulfate. However, this difference was only between the drug and control treatments and not between the drug and placebo treatments.
13) There was no significant difference in endurance performance time on the bicycle ergometer after being administered 0.14 mg. per kilogram of body weight of dextroamphetamine sulfate.
14) There was no significant difference in ratings of perceived exertion during exercise on the bicycle ergometer after being administered 0.14 mg. per kilogram of body weight of dextroamphetamine sulfate.

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APPENDIX A - STATISTICAL ANALYSES OF THE DATA

TABLE 9

ANALYSIS OF VARIANCE FOR AGE VALUES

Source of Variation	Sum of Squares	Degrees of Freedom	Mean Square	F Ratio
Groups	32.10	2	16.05	1.05
Error	137.02	9	15.22	

A F of 4.26 was required for significance at the 0.05 level.

TABLE 10

ANALYSIS OF VARIANCE FOR HEIGHT VALUES

Source of Variation	Sum of Squares	Degrees of Freedom	Mean Square	F Ratio
Groups	41.88	2	20.94	0.27
Error	707.25	9	78.58	

A F of 4.26 was required for significance at the 0.05 level.

TABLE 11

ANALYSIS OF VARIANCE FOR WEIGHT VALUES

Source of Variation	Sum of Squares	Degrees of Freedom	Mean Square	F Ratio
Groups	301.25	2	150.63	3.75
Error	361.56	9	40.17	

A F of 4.26 was required for significance at the 0.05 level.

TABLE 12

ANALYSIS OF VARIANCE FOR MAXIMUM HEART RATE VALUES

Source of Variation	Sum of Squares	Degrees of Freedom	Mean Square	F Ratio
Groups	190.50	2	95.25	1.42
Error	603.75	9	67.08	

A F of 4.26 was required for significance at the 0.05 level.

TABLE 13

ANALYSIS OF VARIANCE FOR HEART RATE VALUES AT REST

Source of Variation	Sum of Squares	Degrees of Freedom	Mean Square	F Ratio
Between Subjects				
Groups	86.05	2	43.02	
Subjects w.i Groups	1115.187	9	123.91	
Within Subjects				
A (Session)	30.69	2	15.34	0.89
B (Treatment)	23.72	2	11.86	0.69
(AB)' (Session x Treatment)	50.39	2	25.20	1.46
Error (Within)	309.81	18	17.21	

A F of 3.55 was required for significance at the 0.05 level.

TABLE 14

ANALYSIS OF VARIANCE FOR SYSTOLIC BLOOD PRESSURE VALUES AT REST

Source of Variation	Sum of Squares	Degrees of Freedom	Mean Square	F Ratio
Between Subjects				
Groups	39.00	2	19.5	
Subjects w. Groups	791.69	9	87.97	
Within Subjects				
A (Session)	272.75	2	136.38	2.78
B (Treatment)	72.50	2	36.25	0.74
(AB)' (Session x Treatment)	38.81	2	19.41	0.40
Error (Within)	883.313	18	49.07	

A F of 3.55 was required for significance at the 0.05 level.

TABLE 15

ANALYSIS OF VARIANCE FOR DIASTOLIC BLOOD PRESSURE VALUES AT REST

Source of Variation	Sum of Squares	Degrees of Freedom	Mean Square	F Ratio
Between Subjects				
Groups	438.89	2	219.45	
Subjects w. Groups	325.00	9	36.11	
Within Subjects				
A (Session)	88.88	2	44.44	3.20
B (Treatment)	38.89	2	19.45	1.40
(AB)' (Session x Treatment)	88.86	2	44.43	3.20
Error (Within)	250.00	18	13.89	

A F of 3.55 was required for significance at the 0.05 level.

TABLE 16

ANALYSIS OF VARIANCE FOR OXYGEN UPTAKE VALUES AT REST

Source of Variation	Sum of Squares	Degrees of Freedom	Mean Square	F Ratio
Between Subjects				
Groups	4.76	2	2.38	
Subjects w. Groups	31.24	9	3.47	
Within Subjects				
A (Session)	0.84	2	0.42	0.33
B (Treatment)	0.13	2	0.07	0.05
(AB)' (Session x Treatment)	3.40	2	1.70	1.32
Error (Within)	23.25	18	1.29	

A F of 3.55 was required for significance at the 0.05 level.

TABLE 17

ANALYSIS OF VARIANCE FOR ENDURANCE PERFORMANCE TIME

Source of Variation	Sum of Squares	Degrees of Freedom	Mean Square	F Ratio
Between Subjects				
Groups	1515.5	2	757.75	
Subjects w. Groups	5068.5	9	563.17	
Within Subjects				
A (Session)	468.49	2	234.25	4.68*
B (Treatment)	216.50	2	108.25	2.16
(AB)' (Session x Treatment)	186.0	2	93.00	1.86
Error (Within)	900.99	18	50.06	

A F of 3.55 was required for significance at the 0.05 level.
* Significant at the 0.05 level

TABLE 18

SCHEFFÉ TEST FOR SESSION MEANS FOR ENDURANCE PERFORMANCE TIME

Session 1	Session 2	Session 3	Mean Difference
25.50	24.75		0.75
25.50		32.75	7.25
	24.75	32.75	8.00*

A Mean Difference of 7.77 was required for significance at the 0.05 level.
* Significant at the 0.05 level

TABLE 19

ANALYSIS OF VARIANCE FOR HEART RATE VALUES DURING EXERCISE

Source of Variation	Sum of Squares	Degrees of Freedom	Mean Square	F Ratio
Between Subjects				
Groups	3170.0	2	1585.0	
Subjects w. Groups	2565.0	9	285.0	
Within Subjects				
A (Session)	147.0	2	73.5	3.68*
B (Treatment)	375.0	2	187.5	9.38*
(AB)'	49.0	2	24.5	1.23
Res. 1 (B x Subj. w. Groups)	208.0	18	11.56	
C (Time)	2324.0	1	2324.0	116.2*
C x Groups	61.0	2	30.50	1.53
Res. 2 (SS_C x Subj. w. Groups)	435.0	9	48.33	
AC	73.0	2	36.5	1.83
BC	79.0	2	39.5	1.98
(AB')C	20.0	2	10.0	0.5
Res. 3 (SS_{BC} x Subj. w. Groups)	257.0	18	14.28	

F's of 3.20 (DF of 2, 45) and 4.05 (DF of 1, 45) were required for significance at the 0.05 level.
* Significant at the 0.05 level

TABLE 20

SCHEFFÉ TEST FOR TREATMENT MEANS FOR HEART RATE DURING EXERCISE

Treatment 1	Treatment 2	Treatment 3	Mean Difference
171.33	176.83		5.50*
171.33		173.21	1.80
	176.83	173.21	3.62*

A Mean Difference of 3.20 was required for significance at the 0.05 level.
* Significant at the 0.05 level

TABLE 21

SCHEFFÉ TEST FOR SESSION MEANS FOR HEART RATE DURING EXERCISE

Session 1	Session 2	Session 3	Mean Difference
175.46	173.92		1.54
175.46		172.00	3.46*
	173.92	172.00	1.92

A Mean Difference of 3.20 was required for significance at the 0.05 level.
* Significant at the 0.05 level

TABLE 22

ANALYSIS OF VARIANCE FOR SYSTOLIC BLOOD PRESSURE VALUES DURING EXERCISE

Source of Variation	Sum of Squares	Degrees of Freedom	Mean Square	F Ratio
Between Subjects				
Groups	2953.0	2	1476.5	
Subjects w. Groups	6320.0	9	706.89	
Within Subjects				
A (Session)	140.0	2	70.0	0.57
B (Treatment)	636.0	2	318.0	2.57
(AB)'	82.0	2	41.0	0.33
Res. 1 (B x Subj. w. Groups)	3376.0	18	187.56	
C (Time)	401.0	1	401.0	3.24
C x Groups	2.0	2	1.0	0.008
Res. 2 (SS_C x Subj. w. Groups)	1047.0	9	116.33	
AC	1.0	2	0.5	0.004
BC	102.0	2	51.0	0.41
(AB)C'	257.0	2	128.5	1.04
Res. 3 (SS_{BC} x Subj. w. Groups)	1140.0	18	63.33	

F's of 3.20 (DF of 2, 45) and 4.05 (DF of 1, 45) were required for significance at the 0.05 level.

TABLE 23

ANALYSIS OF VARIANCE FOR DIASTOLIC BLOOD PRESSURE VALUES DURING EXERCISE

Source of Variation	Sum of Squares	Degrees of Freedom	Mean Square	F Ratio
Between Subjects				
Groups	1536.13	2	768.06	
Subjects w. Groups	758.38	9	84.26	
Within Subjects				
A (Session)	269.44	2	134.72	5.09*
B (Treatment)	52.81	2	26.41	1.00
(AB)'	311.12	2	155.56	5.87*
Res. 1 (B x Subj. w. Groups)	866.63	18	48.15	
C (Time)	50.00	1	50.00	1.89
C x Groups	8.38	2	4.19	0.16
Res. 2 (SS_C x Subj. w. Groups)	108.25	9	12.03	
AC	8.25	2	4.13	0.16
BC	8.31	2	4.16	0.16
(AB')C	0.06	2	0.03	0.001
Res. 3 (SS_{BC} x Subj. w. Groups)	216.75	18	12.04	

F's of 3.20 (DF of 2, 45) and 4.05 (DF of 1, 45) were required for significance at the 0.05 level.
* Significant at the 0.05 level

TABLE 24

SCHEFFÉ TEST FOR SESSION MEANS FOR DIASTOLIC BLOOD PRESSURE DURING EXERCISE

Session 1	Session 2	Session 3	Mean Difference
54.58	57.92		3.34
54.58		53.34	1.24
	57.92	53.34	4.58*

A Mean Difference of 3.68 was required for significance at the 0.05 level.
* Significant at the 0.05 level

TABLE 25

SCHEFFÉ TEST FOR SESSION x TREATMENT MEANS FOR DIASTOLIC BLOOD PRESSURE DURING EXERCISE

S_1Tr_1	S_2Tr_1	S_3Tr_1	S_1Tr_2	S_2Tr_2	S_3Tr_2	S_1Tr_3	S_2Tr_3	S_3Tr_3	Mean Difference
48.75	60.00								11.25*
48.75		53.75							5.00
48.75			51.25						2.50
48.75				55.00					6.25
48.75					60.00				11.25*
48.75						63.75			15.00*
48.75							58.75		10.00*
48.75								46.25	2.50
	60.00	53.75							6.25
	60.00		51.25						8.75
	60.00			55.00					5.00
	60.00				60.00				0.00
	60.00					63.75			3.75
	60.00						58.75		1.25
	60.00							46.25	13.75*
		53.75	51.25						2.50
		53.75		55.00					1.25
		53.75			60.00				6.25
		53.75				63.75			10.00*
		53.75					58.75		5.00
		53.75						46.25	7.50
			51.25	55.00					3.75
			51.25		60.00				9.75
			51.25			63.75			12.50*
			51.25				58.75		7.50
			51.25					46.25	5.00

TABLE 25

(CONTINUED)

S_1Tr_1	S_2Tr_1	S_3Tr_1	S_1Tr_2	S_2Tr_2	S_3Tr_2	S_1Tr_3	S_2Tr_3	S_3Tr_3	Mean Difference
				55.00	60.00				5.00
				55.00		63.75			8.75
				55.00			58.75		3.75
				55.00				46.25	8.75
					60.00	63.75			3.75
					60.00		58.75		1.25
					60.00			46.25	15.75*
						63.75	58.75		5.00
						63.75		46.25	17.50*
							58.75	46.25	12.50*

A Mean Difference of 9.84 was required for significance at the 0.10 level.
* Significant at the 0.10 level

TABLE 26

ANALYSIS OF VARIANCE FOR OXYGEN UPTAKE VALUES DURING EXERCISE

Source of Variation	Sum of Squares	Degrees of Freedom	Mean Square	F Ratio
Between Subjects				
Groups	922.19	2	461.09	
Subjects w. Groups	232.00	9	25.78	
Within Subjects				
A (Session)	274.38	2	137.19	3.21*
B (Treatment)	255.81	2	127.91	3.00
(AB)'	238.50	2	119.25	2.79
Res. 1 (B x Subj. w. Groups)	446.0	18	24.78	
C (Time)	262.69	1	262.69	6.15*
C x Groups	56.31	2	28.16	0.66
Res. 2 (SS_C x Subj. w. Groups)	781.56	9	86.84	
AC	38.06	2	19.03	0.45
BC	4.25	2	2.13	0.05
(AB')C	60.00	2	30.00	0.70
Res. 3 (SS_{BC} x Subj. w. Groups)	637.44	18	35.41	

F's of 3.20 (DF of 2, 45) and 4.05 (DF of 1, 45) were required for significance at the 0.05 level.
* Significant at the 0.05 level

TABLE 27

SCHEFFÉ TEST FOR SESSION MEANS FOR OXYGEN UPTAKE DURING EXERCISE

Session 1	Session 2	Session 3	Mean Difference
45.06	44.10		0.96
45.06		40.52	4.54*
	44.10	40.52	3.58

A Mean Difference of 4.08 was required for significance at the 0.10 level.
* Significant at the 0.10 level

TABLE 28

ANALYSIS OF VARIANCE FOR PERCEIVED EXERTION VALUES DURING EXERCISE

Source of Variation	Sum of Squares	Degrees of Freedom	Mean Square	F Ratio
Between Subjects				
Groups	0.46	2	0.23	
Subjects w. Groups	94.30	9	10.48	
Within Subjects				
A (Session)	0.13	2	0.66	0.43
B (Treatment)	4.57	2	2.29	1.48
(AB)'	3.02	2	1.51	0.97
Res. 1 (B x Subj. w. Groups)	33.61	18	1.87	
C (Time)	612.35	2	306.18	197.54*
C x Groups	20.37	4	5.09	3.28*
Res. 2 (SS_C x Subj. w. Groups)	59.28	18	3.29	
AC	0.86	4	0.21	0.14
BC	7.26	4	1.82	1.17
(AB')C	2.66	4	0.67	0.43
Res. 3 (SS_{BC} x Subj. w. Groups)	18.56	36	0.52	

F's of 3.13 (DF of 2, 72) and 2.50 (DF of 4, 72) were required for significance at the 0.05 level.
* Significant at the 0.05 level

TABLE 29

SCHEFFÉ TEST FOR TIME MEANS FOR PERCEIVED EXERTION DURING EXERCISE

Time 1	Time 2	Time 3	Mean Difference
13.03	15.06		2.03*
13.03		18.78	5.75*
	15.06	18.78	3.72*

A Mean Difference of 0.76 was required for significance at the 0.05 level.
* Significant at the 0.05 level

TABLE 30

SCHEFFÉ TEST FOR TIME x GROUP MEANS FOR PERCEIVED EXERTION DURING EXERCISE

Gp_1T_1	Gp_2T_1	Gp_3T_1	Gp_1T_2	Gp_2T_2	Gp_3T_2	Gp_1T_3	Gp_2T_3	Gp_3T_3	Mean Difference
13.08	12.83								0.25
13.08		13.17							0.09
13.08			14.92						1.84
13.08				15.83					2.75*
13.08					14.42				1.34
13.08						18.58			5.50*
13.08							18.33		5.25*
13.08								19.42	6.34*
	12.83	13.17							0.34
	12.83		14.92						2.09*
	12.83			15.83					3.00*
	12.83				14.42				1.59
	12.83					18.58			5.75*
	12.83						18.33		5.50*
	12.83							19.42	6.59*
		13.17	14.92						1.75
		13.17		15.83					2.66*
		13.17			14.42				1.25
		13.17				18.58			5.41*
		13.17					18.33		5.16*
		13.17						19.42	6.25*
			14.92	15.83					0.91
			14.92		14.42				0.50
			14.92			18.58			3.66*
			14.92				18.33		3.41*
			14.92					19.42	4.50*

TABLE 30

(CONTINUED)

Gp_1T_1	Gp_2T_1	Gp_3T_1	Gp_1T_2	Gp_2T_2	Gp_3T_2	Gp_1T_3	Gp_2T_3	Gp_3T_3	Mean Difference
				15.83	14.42				1.41
				15.83		18.58			2.75*
				15.83			18.33		2.50*
				15.83				19.42	3.39*
					14.42	18.58			4.16*
					14.42		18.33		3.91*
					14.42			19.42	5.00*
						18.58	18.33		0.25
						18.58		19.42	0.84
							18.33	19.42	1.09

A Mean Difference of 1.93 was required for significance at the 0.10 level.
* Significant at the 0.10 level

TABLE 31

ANALYSIS OF VARIANCE FOR HEART RATE VALUES DURING RECOVERY FROM EXERCISE

Source of Variation	Sum of Squares	Degrees of Freedom	Mean Square	F Ratio
Between Subjects				
Groups	1464.0	2	732.0	
Subjects w. Groups	4448.0	9	494.22	
Within Subjects				
A (Session)	116.0	2	58.0	1.06
B (Treatment)	3152.0	2	1576.0	28.92*
(AB)'	133.0	2	66.50	1.22
Res. 1 (B x Subj. w. Groups)	1384.0	18	76.89	
C (Time)	1793.0	2	896.50	16.45*
C x Groups	430.0	4	107.50	1.97
Res. 2 (SS_C x Subj. w. Groups)	1350.0	18	75.00	
AC	215.0	4	53.75	0.99
BC	173.0	4	43.25	0.79
(AB')C	80.0	4	20.00	0.37
Res. 3 (SS_{BC} x Subj. w. Groups)	1189.0	36	33.03	

F's of 3.13 (DF of 2, 72) and 2.50 (DF of 4, 72) were required for significance at the 0.05 level.
* Significant at the 0.05 level

TABLE 32

SCHEFFÉ TEST FOR TREATMENT MEANS FOR HEART RATE DURING RECOVERY FROM EXERCISE

Treatment 1	Treatment 2	Treatment 3	Mean Difference
100.139	111.750		11.61*
100.139		100.444	0.31
	111.750	100.444	11.31*

A Mean Difference of 4.52 was required for significance at the 0.05 level.
* Significant at the 0.05 level

TABLE 33

SCHEFFÉ TEST FOR TIME MEANS FOR HEART RATE DURING RECOVERY FROM EXERCISE

Time 1	Time 2	Time 3	Mean Difference
108.97	104.36		4.61*
108.97		99.00	9.97*
	104.36	99.00	5.36*

A Mean Difference of 4.52 was required for significance at the 0.05 level.
* Significant at the 0.05 level

TABLE 34

ANALYSIS OF VARIANCE FOR SYSTOLIC BLOOD PRESSURE VALUES DURING RECOVERY FROM EXERCISE

Source of Variation	Sum of Squares	Degrees of Freedom	Mean Square	F Ratio
Between Subjects				
Groups	505.0	2	252.50	
Subjects w. Groups	1828.0	9	203.11	
Within Subjects				
A (Session)	1006.0	2	503.0	9.60*
B (Treatment)	705.0	2	352.50	6.73*
(AB)'	149.0	2	74.50	1.42
Res. 1 (B x Subj. w. Groups)	2007.0	18	111.50	
C (Time)	2600.0	2	1300.00	24.81*
C x Groups	44.0	4	11.00	0.21
Res. 2 (SS_C x Subj. w. Groups)	823.0	18	45.72	
AC	260.0	4	65.00	1.24
BC	127.0	4	31.75	0.61
(AB')C	271.0	4	67.75	1.29
Res. 3 (SS_{BC} x Subj. w. Groups)	942.0	36	26.17	

F's of 3.13 (DF of 2, 72) and 2.50 (DF of 4, 72) were required for significance at the 0.05 level.
* Significant at the 0.05 level

TABLE 35

SCHEFFÉ TEST FOR TREATMENT MEANS FOR SYSTOLIC BLOOD PRESSURE DURING RECOVERY FROM EXERCISE

Treatment 1	Treatment 2	Treatment 3	Mean Difference
120.28	125.83		5.55*
120.28		120.56	0.28
	125.83	120.56	5.27*

A Mean Difference of 4.44 was required for significance at the 0.05 level.
* Significant at the 0.05 level

TABLE 36

SCHEFFÉ TEST FOR TIME MEANS FOR SYSTOLIC BLOOD PRESSURE DURING RECOVERY FROM EXERCISE

Time 1	Time 2	Time 3	Mean Difference
128.89	120.56		8.33*
128.89		117.22	11.67*
	120.56	117.22	3.34*

A Mean Difference of 4.44 was required for significance at the 0.05 level.
* Significant at the 0.05 level

TABLE 37

SCHEFFÉ TEST FOR SESSION MEANS FOR SYSTOLIC BLOOD PRESSURE DURING RECOVERY FROM EXERCISE

Session 1	Session 2	Session 3	Mean Difference
123.33	125.28		1.95
123.33		118.06	4.73*
	125.28	118.06	7.22*

A Mean Difference of 4.44 was required for significance at the 0.05 level.
* Significant at the 0.05 level

TABLE 38

ANALYSIS OF VARIANCE FOR DIASTOLIC BLOOD PRESSURE VALUES DURING RECOVERY FROM EXERCISE

Source of Variation	Sum of Squares	Degrees of Freedom	Mean Square	F Ratio
Between Subjects				
Groups	1096.31	2	548.16	
Subjects w. Groups	936.13	9	104.01	
Within Subjects				
A (Session)	135.19	2	67.59	2.65
B (Treatment)	57.44	2	28.72	1.12
(AB)'	24.06	2	12.03	0.47
Res. 1 (B x Subj. w. Groups)	738.88	18	41.05	
C (Time)	24.13	2	12.06	0.47
C x Groups	59.25	4	14.81	0.58
Res. 2 (SS_C x Subj. w. Groups)	405.50	18	22.53	
AC	86.94	4	21.73	0.85
BC	131.44	4	32.86	1.29
(AB')C	64.94	4	16.24	0.64
Res. 3 (SS_{BC} x Subj. w. Groups)	694.50	36	19.29	

F's of 3.13 (DF of 2, 72) and 2.50 (DF of 4, 72) were required for significance at the 0.05 level.

TABLE 39

ANALYSIS OF VARIANCE FOR OXYGEN UPTAKE VALUES DURING RECOVERY FROM EXERCISE

Source of Variation	Sum of Squares	Degrees of Freedom	Mean Square	F Ratio
Between Subjects				
Groups	2.08	2	1.04	
Subjects w. Groups	41.72	9	4.64	
Within Subjects				
A (Session)	7.51	2	3.76	4.37*
B (Treatment)	14.44	2	7.22	8.40*
(AB)'	1.96	2	0.98	1.14
Res. 1 (B x Subj. w. Groups)	21.29	18	1.18	
C (Time)	30.72	2	15.36	17.86*
C x Groups	4.29	4	1.07	1.24
Res. 2 (SS$_C$ x Subj. w. Groups)	10.64	18	0.59	
AC	2.33	4	0.58	0.67
BC	3.83	4	0.96	1.12
(AB')C	0.98	4	0.25	0.29
Res. 3 (SS$_{BC}$ x Subj. w. Groups)	30.19	36	0.84	

F's of 3.13 (DF of 2, 72) and 2.50 (DF of 4, 72) were required for significance at the 0.05 level.
* Significant at the 0.05 level

TABLE 40

SCHEFFÉ TEST FOR TREATMENT MEANS FOR OXYGEN UPTAKE DURING RECOVERY FROM EXERCISE

Treatment 1	Treatment 2	Treatment 3	Mean Difference
5.51	6.38		0.87*
5.51		6.15	0.64*
	6.38	6.15	0.23

A Mean Difference of 0.57 was required for significance at the 0.05 level.
* Significant at the 0.05 level

TABLE 41

SCHEFFÉ TEST FOR TIME MEANS FOR OXYGEN UPTAKE DURING RECOVERY FROM EXERCISE

Time 1	Time 2	Time 3	Mean Difference
6.77	5.69		1.08*
6.77		5.58	1.19*
	5.69	5.58	0.11

A Mean Difference of 0.57 was required for significance at the 0.05 level.
* Significant at the 0.05 level

TABLE 42

SCHEFFÉ TEST FOR SESSION MEANS FOR OXYGEN UPTAKE DURING RECOVERY FROM EXERCISE

Session 1	Session 2	Session 3	Mean Difference
5.84	6.39		0.55
5.84		5.82	0.02
	6.39	5.82	0.57*

A Mean Difference of 0.57 was required for significance at the 0.05 level.
* Significant at the 0.05 level

TABLE 43

ANALYSIS OF VARIANCE FOR RESTING AND FIFTEENTH MINUTE OF RECOVERY HEART RATE VALUES

Source of Variation	Sum of Squares	Degrees of Freedom	Mean Square	F Ratio
Between Subjects				
Groups	646.25	2	323.13	
Subjects w. Groups	2500.75	9	277.86	
Within Subjects				
A (Session)	67.19	2	33.59	1.03
B (Treatment)	563.13	2	281.56	8.64*
(AB)'	107.69	2	53.85	1.65
Res. 1 (B x Subj. w. Groups)	502.00	18	27.89	
C (Time)	27456.0	1	27456.0	842.73*
C x Groups	199.38	2	99.69	3.06
Res. 2 (SS_C x Subj. w. Groups)	440.94	9	48.99	
AC	27.38	2	13.69	0.42
BC	284.19	2	142.09	4.36*
(AB')C	53.81	2	26.91	0.83
Res. 3 (SS_{BC} x Subj. w. Groups)	523.31	18	29.07	

F's of 3.20 (DF of 2, 45) and 4.05 (DF of 1, 45) were required for significance at the 0.05 level.
* Significant at the 0.05 level

TABLE 44

SCHEFFÉ TEST FOR TREATMENT MEANS FOR RESTING AND FIFTEENTH MINUTE OF RECOVERY HEART RATES

Treatment 1	Treatment 2	Treatment 3	Mean Difference
77.75	83.42		5.67*
77.75		77.25	0.50
	83.42	77.25	6.17*

A Mean Difference of 4.08 was required for significance at the 0.05 level.
* Significant at the 0.05 level

TABLE 45

SCHEFFÉ TEST FOR TREATMENT x TIME MEANS FOR RESTING AND FIFTEENTH MINUTE OF RECOVERY HEART RATES

Tr_1T_1	Tr_2T_1	Tr_3T_1	Tr_1T_2	Tr_2T_2	Tr_3T_2	Mean Difference
59.50	61.08					1.58
59.50		59.25				0.25
59.50			96.00			36.50*
59.50				105.75		46.25*
59.50					95.25	35.75*
	61.08	59.25				1.83
	61.08		96.00			34.92*
	61.08			105.75		44.67*
	61.08				95.25	34.17*
		59.25	96.00			36.75*
		59.25		105.75		46.50*
		59.25			95.25	36.00*
			96.00	105.75		9.75*
			96.00		95.25	0.75
				105.75	95.25	10.50*

A Mean Difference of 7.44 was required for significance at the 0.10 level.
* Significant at the 0.10 level

TABLE 46

ANALYSIS OF VARIANCE FOR RESTING AND FIFTEENTH MINUTE OF RECOVERY SYSTOLIC BLOOD PRESSURE VALUES

Source of Variation	Sum of Squares	Degrees of Freedom	Mean Square	F Ratio
Between Subjects				
Groups	174.88	2	87.44	
Subjects w. Groups	896.0	9	99.56	
Within Subjects				
A (Session)	435.13	2	217.56	5.83*
B (Treatment)	132.88	2	66.44	1.78
(AB)'	7.18	2	3.59	0.10
Res. 1 (B x Subj. w. Groups)	791.5	18	43.97	
C (Time)	168.0	1	168.0	4.50*
C x Groups	136.3	2	68.16	1.83
Res. 2 (SS_C x Subj. w. Groups)	345.69	9	38.41	
AC	11.13	2	5.56	0.15
BC	78.31	2	39.16	1.05
(AB')C	69.50	2	34.75	0.93
Res. 3 (SS_{BC} x Subj. w. Groups)	542.13	18	30.19	

F's of 3.20 (DF of 2, 45) and 4.05 (DF of 1, 45) were required for significance at the 0.05 level.
* Significant at the 0.05 level

TABLE 47

SCHEFFÉ TEST FOR SESSION MEANS FOR RESTING AND FIFTEENTH MINUTE OF RECOVERY SYSTOLIC BLOOD PRESSURES

Session 1	Session 2	Session 3	Mean Difference
121.25	119.58		1.67
121.25		115.92	5.33*
	119.58	115.92	3.66

A Mean Difference of 4.37 was required for significance at the 0.05 level.
* Significant at the 0.05 level

TABLE 48

ANALYSIS OF VARIANCE FOR RESTING AND FIFTEENTH MINUTE OF RECOVERY DIASTOLIC BLOOD PRESSURE VALUES

Source of Variation	Sum of Squares	Degrees of Freedom	Mean Square	F Ratio
Between Subjects				
Groups	686.13	2	343.06	
Subjects w. Groups	575.0	9	63.89	
Within Subjects				
A (Session)	144.44	2	72.22	3.72*
B (Treatment)	77.81	2	38.91	2.00
(AB)'	86.12	2	43.06	2.22
Res. 1 (B x Subj. w. Groups)	525.0	18	29.17	
C (Time)	88.94	1	88.94	4.58*
C x Groups	19.44	2	9.72	0.50
Res. 2 (SS_C x Subj. w. Groups)	91.63	9	10.18	
AC	11.00	2	5.50	0.28
BC	11.06	2	5.53	0.28
(AB')C	19.56	2	9.78	0.50
Res. 3 (SS_{BC} x Subj. w. Groups)	258.38	18	14.35	

F's of 3.20 (DF of 2, 45) and 4.05 (DF of 1, 45) were required for significance at the 0.05 level.
* Significant at the 0.05 level

TABLE 49

SCHEFFÉ TEST FOR SESSION MEANS FOR RESTING AND FIFTEENTH MINUTE OF RECOVERY DIASTOLIC BLOOD PRESSURES

Session 1	Session 2	Session 3	Mean Difference
55.84	56.67		0.83
55.84		53.34	2.50
	56.67	53.34	3.33*

A Mean Difference of 3.15 was required for significance at the 0.05 level.
* Significant at the 0.05 level

TABLE 50

ANALYSIS OF VARIANCE FOR RESTING AND FIFTEENTH MINUTE OF RECOVERY OXYGEN UPTAKE VALUES

Source of Variation	Sum of Squares	Degrees of Freedom	Mean Square	F Ratio
Between Subjects				
Groups	2.36	2	1.18	
Subjects w. Groups	43.85	9	4.87	
Within Subjects				
A (session)	4.42	2	2.21	1.89
B (Treatment)	2.26	2	1.13	0.97
(AB)'	2.26	2	1.13	0.97
Res. 1 (B x Subj. w. Groups)	25.00	18	1.39	
C (Time)	24.01	1	24.01	20.52*
C x Groups	5.20	2	2.60	2.22
Res. 2 (SS_C x Subj. w. Groups)	8.76	9	0.97	
AC	0.15	2	0.075	0.06
BC	2.35	2	1.17	1.00
(AB')C	0.53	2	0.27	0.23
Res. 3 (SS_{BC} x Subj. w. Groups)	19.0	18	1.06	

F's of 3.20 (DF of 2, 45) and 4.05 (DF of 1, 45) were required for significance at the 0.05 level.
* Significant at the 0.05 level

TABLE 51

T-TEST FOR PREDICTED AND ACTUAL HEART RATES

Means	Standard Deviations	T Value for Means
163.67	7.4	±.748
165.42	11.6	

A T of 2.20 was required for significance at the 0.05 level.

APPENDIX B

APL PROGRAM FOR COMPUTING PREDICTED WORK LOADS

```
    ∇PWL
 [1] Y←Wx6xP
 [2] SH←Hx0.9
 [3] SXY← +/(XxY)
 [4] SXSY← (+/X)x(+/Y)
 [5] N←ρX
 [6] SXS←+/(X*2)
 [7] SXSS← (+/X)*2
 [8] SY←+/Y
 [9] BYX←SXY-(SXSY÷N)
[10] BYX← BYX÷(SXS-(SXSS÷N))
[11] AYX← (SY-(BYXx(+/X)))÷N
[12] YP← (BYXxSH)+AYX
[13] WLS←YP÷360
[14] ID
[15] 'MAX HEART RATE IS';H
[16] '90 PERCENT OF ABOVE IS';SH
[17] 'CORRECTED WORK LOADS ARE';Y
[18] 'WORK LOAD TO PEDAL AT IS';YP
[19] 'WORK LOAD TO PEDAL AT 60 RPM IS';WLS
    ∇
```

APPENDIX C

APL PROGRAM FOR COMPUTING OXYGEN UPTAKE

```
   ∇VO2
 [1] POE←Ox2.5
 [2] N←100-(POE+C)
 [3] POI←Nx.2648
 [4] POC←(POI-POE)÷100
 [5] V←Mx.1332
 [6] CV←VxSTPD
 [7] VO2L←CVxPOC
 [8] VO2ML←(VO2Lx1000)÷KG
 [9] ID
[10] 'VO2 IN LITERS PER MINUTE IS';VO2L
[11] 'VO2 IN ML PER KG PER MINUTE IS';VO2ML
   ∇
```

APPENDIX D

INFORMED CONSENT FORM

University of Alberta

Department of Physical Education

NAME:

BIRTHDATE:

ADDRESS:

TELEPHONE NUMBER:

The purpose of this study is to investigate the effects of dextroamphetamine sulfate on selected physiological, psychological, and physical performance parameters of male athletes in the non-competitive season. The specific parameters to be investigated are: physiological - heart rate, blood pressure, and oxygen uptake; psychological - subjective rating of perceived exertion; and physical performance - endurance performance time on the bicycle ergometer.

Initially, a preliminary testing session involving a progressive work load test on the bicycle ergometer will be completed by each subject. The test protocol for the following three testing sessions will be completed by each subject once without taking either dextroamphetamine sulfate or the placebo, once after taking the drug, and once after taking the placebo. The drug will be administered orally by dissolving such in eight ounces of orange juice. Each subject will receive 0.14 mg. per kilogram of body weight of dextroamphetamine sulfate.

Participants are advised of the following:

Dextroamphetamine sulfate, the d-isomer of amphetamine, is a

sympathomimetic drug with predominantly central nervous system action and weak peripheral sympathomimetic effects. The main pharmacological actions of oral administration of amphetamines in usual therapeutic doses of five to thirty milligrams are: central nervous system effects - stimulation of the central nervous system including attentiveness, alertness, concentration, and decreased sense of fatigue; peripheral effects - include an increase in heart rate and blood pressure, respiratory stimulation, pupillary dilatation; relaxation of the smooth muscles of the gastrointestinal tract, bronchioles, and urinary bladder; and an increase in blood sugar level.

Acute toxic effects of amphetamines are usually the result of a single dose that is many times larger than the therapeutic dose levels. The central nervous system effects may include restlessness, dizziness, insomnia, irritability, anxiety, tenseness, and nervousness. Cardiovascular effects include headache, pallor or flushing, chilliness, cardiac arrhythmias, hypertension or hypotension, and palpitation. Gastrointestinal effects include nausea, anorexia, and dry mouth.

The purpose and procedure of the study has been explained to me and I fully understand such. I hereby agree to participate in the above mentioned study. I hereby specifically agree to hold the University of Alberta and all investigators of this study legally blameless for any accident that I may incur.

I have read and fully understand the above.

WITNESS AND DATE OF SIGNING

SIGNATURE AND DATE OF SIGNING

APPENDIX E

INSTRUCTIONS TO SUBJECTS FOR PRELIMINARY TESTING SESSION

This test is a progressive work load test to maximum on the bicycle ergometer. You are to cycle at 60 revolutions per minute (following the metronome) at an initial low work load of one kilopond for four minutes duration. The work load will be increased by either one-half of a kilopond or one kilopond every four minutes. You are to continue cycling until you can no longer perform the task. Your heart rate will be recorded between three and one-half and four minutes of every work load during the test. Your performance on the test will be compared with the performances of all the other subjects.

APPENDIX F

INSTRUCTIONS TO SUBJECTS FOR THE THREE TESTING SESSIONS

The three testing sessions will involve the following test protocol:

Resting measurements of heart rate, blood pressure, and oxygen uptake will be taken 30 minutes after orally ingesting 0.14 mg. per kilogram of body weight of dextroamphetamine sulfate, after ingesting the placebo, or after ingesting neither. The drug will be dissolved in eight ounces of orange juice.

Exercise on the bicycle ergometer will be done at a predetermined constant work load. A two minute warm-up at 0.5 and 1.0 kiloponds will precede the exercise. It is important to maintain the pace at 60 revolutions per minute during the exercise. Cycle for as long as you can and tell me when you can no longer continue. Exercise measurements of heart rate, blood pressure, and oxygen uptake will be taken at specific time intervals during exercise.

Recovery measurements of heart rate, blood pressure, and oxygen uptake will be taken 5, 10, and 15 minutes following the end of exercise.

Every subject will respond to a rating scale of perceived exertion at specific time intervals during exercise. The following page provides an explanation of the rating scale.

THE RPE SCALE FOR RATINGS OF PERCEIVED EXERTION

6	
7	Very, very light
8	
9	Very light
10	
11	Fairly light
12	
13	Somewhat hard
14	
15	Hard
16	
17	Very Hard
18	
19	Very, very hard
20	

You now see in front of you a scale which contains numbers from 6 to 20. The scale is used for you to translate into numbers your feelings of exertion during exercise. The range of numbers should represent a range of feelings from no exertion (number 6) to maximal exertion (number 20). To assist you in selecting a number which corresponds to your subjective feelings, every other number on the scale has a verbal expression of the degree of exertion corresponding to that number. It is important that you rate your subjective feelings of exertion which are caused by the work and not the work itself. These feelings should be general, that is, relating to the whole body. You are to select a number which you feel most accurately corresponds to your perception of your total body feeling. There are no right or wrong answers. Therefore, choose the number that you feel is most appropriate.

APPENDIX G

TABLE 52

CALIBRATION CURVE FOR URINE ANALYSIS

Ratio (Actual)	Drug	Standard	Ratio (Observed)
0.1/1	1 mg. dexedrine	10 mg. n-propylamphetamine	
	0	--	v. small
0.2/1	2 mg. dexedrine	10 mg. n-propylamphetamine	
	33.6	234.9	0.14
	34.2	223.3	0.15
0.4/1	4 mg. dexedrine	10 mg. n-propylamphetamine	
	92.8	510	0.18
0.8/1	8 mg. dexedrine	10 mg. n-propylamphetamine	
	219.0	307.5	0.71

APPENDIX H

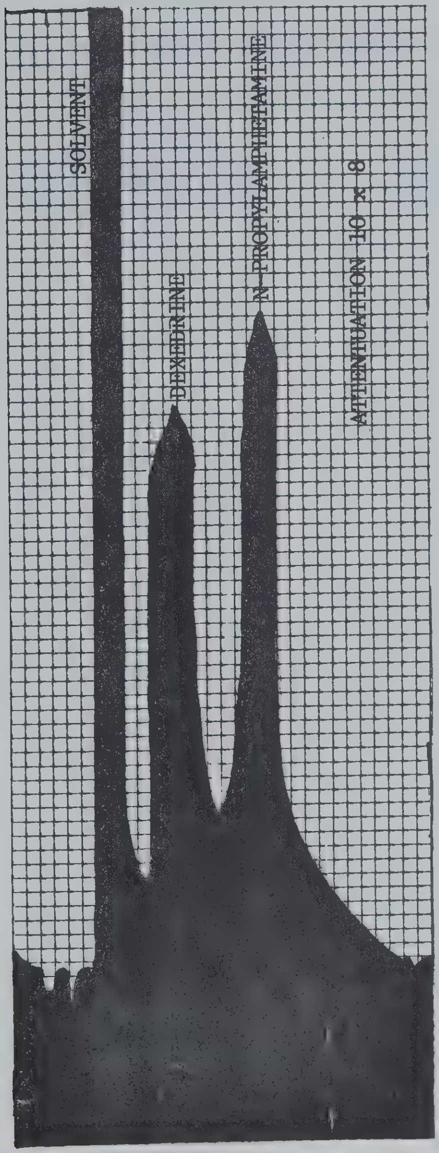

FIGURE 40

TYPICAL CHROMATOGRAPH FOR URINE ANALYSIS

APPENDIX I

TABLE 53

PREDICTED AND ACTUAL HEART RATES (BEATS PER MINUTE)

Subject Number	90% of Maximum Heart Rates from Preliminary Test	Heart Rate at 10th Minute of Exercise (Control Session)
GROUP A		
1	176	180
2	156	155
3	162	176
4	162	164
GROUP B		
5	166	173
6	176	173
7	168	180
8	162	173
GROUP C		
9	150	145
10	156	155
11	162	150
12	168	161
MEAN	163.67	165.42

APPENDIX J

TABLE 54

DOSE OF DRUG ADMINISTERED TO SUBJECTS

Subject Number	Dose in Milligrams
1	11
2	10
3	10
4	10
5	12
6	10
7	10
8	10
9	11
10	11
11	13
12	11

APPENDIX K - RAW DATA

TABLE 55

AGE, HEIGHT, WEIGHT, AND MAXIMUM HEART RATE OF SUBJECTS

Subject Number	Age (Years)	Height (Centimeters)	Weight (Kilograms)	Maximum Heart Rate (Beats per Minute)
GROUP A				
1	18.3	190.5	78.6	195
2	23.0	169.5	71.4	173
3	23.8	172.0	69.5	180
4	27.8	164.0	71.5	180
GROUP B				
5	26.9	185.0	83.0	184
6	33.2	170.2	69.3	195
7	24.0	170.0	70.5	187
8	24.9	183.0	69.6	180
GROUP C				
9	20.1	177.0	81.1	167
10	28.6	180.0	80.5	173
11	25.2	185.9	95.0	180
12	26.8	171.0	77.6	187
MEAN	25.2	176.5	76.5	181.8

TABLE 56

HEART RATE AT REST (BEATS PER MINUTE)

Subject Number	Control	Drug	Placebo
GROUP A			
1	68	67	62
2	55	55	51
3	55	60	59
4	48	65	50
GROUP B			
5	74	71	75
6	63	58	61
7	61	62	61
8	49	51	54
GROUP C			
9	60	57	55
10	55	65	58
11	65	57	55
12	61	65	70
MEAN	59.5	61.1	59.3

TABLE 57

SYSTOLIC BLOOD PRESSURE AT REST (MM. HG.)

Subject Number	Control	Drug	Placebo
GROUP A			
1	130	120	120
2	130	130	120
3	120	120	110
4	110	110	120
GROUP B			
5	120	120	130
6	120	110	120
7	110	120	130
8	130	130	120
GROUP C			
9	110	130	120
10	110	110	130
11	120	130	130
12	110	120	110
MEAN	118.3	120.8	121.7

TABLE 58

DIASTOLIC BLOOD PRESSURE AT REST (MM. HG.)

Subject Number	Control	Drug	Placebo
GROUP A			
1	60	60	50
2	50	50	40
3	50	50	50
4	60	50	50
GROUP B			
5	60	60	60
6	60	50	60
7	60	60	70
8	60	60	60
GROUP C			
9	60	60	60
10	60	50	60
11	50	50	60
12	60	60	60
MEAN	57.5	55.0	56.7

TABLE 59

OXYGEN UPTAKE AT REST (ML./KG./MIN.)

Subject Number	Control	Drug	Placebo
GROUP A			
1	4.54	5.93	4.19
2	4.66	4.38	4.90
3	5.14	2.63	2.22
4	4.49	6.54	4.50
GROUP B			
5	4.01	4.86	4.17
6	2.22	2.26	2.18
7	4.07	3.35	5.09
8	5.17	4.88	5.13
GROUP C			
9	3.70	4.72	8.70
10	6.02	6.12	5.64
11	3.75	3.80	4.50
12	4.64	3.45	2.91
MEAN	4.37	4.41	4.51

TABLE 60

ENDURANCE PERFORMANCE TIME (MINUTES)

Subject Number	Control	Drug	Placebo
GROUP A			
1	35	45	54
2	29	44	65
3	13	20	23
4	17	14	14
GROUP B			
5	20	33	13
6	20	34	24
7	10	14	13
8	13	16	13
GROUP C			
9	50	60	39
10	20	23	29
11	50	50	30
12	20	16	13
MEAN	24.8	30.8	27.5

TABLE 61

HEART RATE DURING EXERCISE (BEATS PER MINUTE)

Subject Number	Control		Drug		Placebo	
	10 Minutes	End	10 Minutes	End	10 Minutes	End
GROUP A						
1	180	195	180	195	180	195
2	155	173	167	187	155	180
3	176	180	173	187	173	180
4	164	173	173	173	164	173
GROUP B						
5	173	187	170	187	180	180
6	173	187	173	195	173	187
7	180	180	180	187	184	187
8	173	180	173	180	180	180
GROUP C						
9	145	161	150	173	148	161
10	155	164	167	180	155	167
11	150	167	161	173	155	167
12	161	180	173	187	180	173
MEAN	165.4	177.3	170.0	183.7	168.9	177.5
	171.3		176.8		173.2	

TABLE 62

SYSTOLIC BLOOD PRESSURE DURING EXERCISE (MM. HG.)

Subject Number	Control		Drug		Placebo	
	10 Minutes	End	10 Minutes	End	10 Minutes	End
GROUP A						
1	180	200	220	220	200	190
2	190	190	180	190	160	190
3	220	210	210	210	220	230
4	170	180	180	180	200	190
GROUP B						
5	170	190	160	200	190	190
6	190	180	180	190	190	190
7	160	160	200	200	170	170
8	180	180	190	190	190	190
GROUP C						
9	190	190	180	200	180	210
10	190	190	190	200	180	190
11	210	210	210	210	200	210
12	200	190	200	200	210	200
MEAN	187.5	189.2	191.7	199.2	190.8	195.8
	188.3		195.4		193.3	

TABLE 63

DIASTOLIC BLOOD PRESSURE DURING EXERCISE (MM. HG.)

Subject Number	Control 10 Minutes	Control End	Drug 10 Minutes	Drug End	Placebo 10 Minutes	Placebo End
GROUP A						
1	60	50	60	60	50	50
2	50	50	50	50	40	30
3	40	40	50	50	50	50
4	50	50	60	60	50	50
GROUP B						
5	60	60	60	60	70	70
6	60	60	60	60	60	50
7	60	60	60	60	70	70
8	60	60	60	60	60	60
GROUP C						
9	50	50	50	40	60	50
10	60	60	40	50	60	60
11	50	50	60	50	60	60
12	60	50	60	60	60	60
MEAN	55.0	53.3	55.8	55.0	57.5	55.0
	54.2		55.4		56.3	

TABLE 64

OXYGEN UPTAKE DURING EXERCISE (ML./KG./MIN.)

Subject Number	Control		Drug		Placebo	
	10 Minutes	End	10 Minutes	End	10 Minutes	End
GROUP A						
1	53.33	41.30	48.03	41.73	39.34	42.04
2	45.71	53.00	43.00	48.38	30.84	46.52
3	37.84	59.85	33.31	47.92	37.37	51.92
4	39.48	51.87	41.67	47.47	45.21	36.83
GROUP B						
5	29.60	40.67	45.20	41.70	46.25	59.90
6	42.56	43.98	41.38	42.05	58.42	46.73
7	53.12	53.12	32.26	56.72	42.65	56.79
8	52.51	48.15	40.01	46.89	58.60	47.57
GROUP C						
9	32.44	38.17	37.62	39.09	43.58	44.75
10	40.35	37.40	46.76	33.58	44.60	45.35
11	35.70	37.12	26.76	34.06	37.41	41.73
12	32.23	42.80	34.70	29.46	37.53	48.32
MEAN	41.27	45.62	39.23	42.42	43.48	47.37
	43.45		40.83		45.43	

TABLE 65

PERCEIVED EXERTION DURING EXERCISE

Subject Number	Control			Drug			Placebo		
	5 Min.	10 Min.	End	5 Min.	10 Min.	End	5 Min.	10 Min.	End
GROUP A									
1	13	16	19	13	14	20	12	13	20
2	13	13	17	11	12	17	11	11	17
3	14	17	18	13	13	18	12	15	19
4	15	17	19	15	19	20	15	19	19
GROUP B									
5	11	13	18	11	15	17	13	17	19
6	15	17	20	13	15	20	13	15	19
7	13	17	17	13	16	18	13	18	18
8	13	16	18	13	16	19	13	15	17
GROUP C									
9	13	14	20	12	12	20	12	14	20
10	15	17	20	13	15	19	12	14	19
11	12	14	20	12	12	20	12	13	20
12	15	16	17	14	15	19	16	17	19
MEAN	13.5	15.6	18.6	12.5	14.5	18.9	12.8	15.1	18.8
		15.9			15.3			15.6	

TABLE 66

HEART RATE DURING RECOVERY FROM EXERCISE (BEATS PER MINUTE)

Subject Number	Control			Drug			Placebo		
	5 Min.	10 Min.	15 Min.	5 Min.	10 Min.	15 Min.	5 Min.	10 Min.	15 Min.
GROUP A									
1	122	113	107	132	127	118	125	107	96
2	94	87	70	115	122	92	129	90	86
3	100	100	85	122	115	105	105	96	102
4	92	91	90	107	92	100	94	80	88
GROUP B									
5	111	113	113	141	114	117	118	110	105
6	113	113	97	115	122	103	111	100	92
7	102	106	107	122	125	123	110	113	115
8	102	105	107	106	98	96	97	98	90
GROUP C									
9	89	88	92	113	113	102	99	91	90
10	99	101	93	118	110	111	110	98	92
11	107	96	90	107	100	92	96	96	95
12	102	107	101	108	110	110	90	110	92
MEAN	102.8	101.7	96.0	117.2	112.3	105.8	107.0	99.1	95.3
		100.1			111.8			100.4	

TABLE 67

SYSTOLIC BLOOD PRESSURE DURING RECOVERY FROM EXERCISE (MM. HG.)

Subject Number	Control			Drug			Placebo		
	5 Min.	10 Min.	15 Min.	5 Min.	10 Min.	15 Min.	5 Min.	10 Min.	15 Min.
GROUP A									
1	140	130	120	130	130	130	130	110	110
2	120	110	110	130	130	110	110	110	110
3	110	120	110	140	130	120	120	120	110
4	120	110	110	130	110	110	130	110	110
GROUP C									
5	140	120	120	140	140	120	110	110	110
6	130	110	120	110	110	110	120	120	130
7	140	120	120	120	120	120	140	130	120
8	150	130	120	130	130	120	130	130	120
GROUP C									
9	120	110	120	130	130	130	130	130	120
10	120	110	110	150	130	120	140	130	120
11	130	120	120	140	130	130	140	120	120
12	120	110	110	130	120	120	120	110	110
MEAN	128.3	116.7	115.8	131.7	125.8	120.0	126.7	119.2	115.8
		120.3			125.8			120.6	

TABLE 68

DIASTOLIC BLOOD PRESSURE DURING RECOVERY FROM EXERCISE (MM. HG.)

Subject Number	Control			Drug			Placebo		
	5 Min.	10 Min.	15 Min.	5 Min.	10 Min.	15 Min.	5 Min.	10 Min.	15 Min.
GROUP A									
1	50	50	50	50	50	60	50	50	50
2	50	50	50	40	40	50	40	40	40
3	50	50	50	50	50	50	50	50	50
4	60	60	60	60	60	50	50	50	50
GROUP B									
5	60	60	60	60	60	60	50	60	60
6	60	60	60	60	60	50	60	60	60
7	50	60	60	60	60	60	60	50	50
8	60	60	60	60	50	50	60	60	60
GROUP C									
9	50	50	60	50	50	60	50	50	50
10	50	50	50	80	50	50	50	50	50
11	50	50	50	60	50	40	60	60	60
12	60	60	60	60	60	60	60	60	60
MEAN	54.2	55.0	55.8	57.5	53.3	53.3	53.3	53.3	53.3
		55.0			54.7			53.3	

TABLE 69

OXYGEN UPTAKE DURING RECOVERY FROM EXERCISE (ML./KG./MIN.)

Subject Number	Control 5 Min.	Control 10 Min.	Control 15 Min.	Drug 5 Min.	Drug 10 Min.	Drug 15 Min.	Placebo 5 Min.	Placebo 10 Min.	Placebo 15 Min.
GROUP A									
1	7.82	5.21	5.92	8.14	6.76	5.94	7.27	5.81	6.03
2	5.60	4.23	5.43	6.92	6.12	6.30	7.29	5.01	3.77
3	5.61	4.63	3.40	6.93	6.78	7.23	7.58	5.48	4.73
4	5.75	6.04	4.33	8.62	6.15	5.46	6.72	4.68	3.88
GROUP B									
5	6.21	5.11	5.50	6.73	6.63	8.55	6.66	6.78	6.80
6	5.08	3.97	3.39	5.89	4.89	5.00	7.82	4.73	4.40
7	7.95	5.14	6.85	6.92	6.43	5.69	8.75	7.15	6.47
8	7.47	7.00	7.05	8.96	6.62	5.14	4.64	5.76	5.45
GROUP C									
9	5.93	5.04	5.67	5.99	4.88	5.22	7.05	5.46	7.58
10	8.01	5.73	6.96	6.05	7.55	7.19	8.64	8.28	5.58
11	5.30	3.79	3.80	6.09	5.93	4.83	6.24	6.07	5.36
12	5.41	3.31	4.87	5.80	4.87	6.36	5.76	6.97	4.91
MEAN	6.35	4.93	5.26	6.92	6.13	6.08	7.04	6.02	5.41
		5.51			6.38			6.16	

TABLE 70

RESTING AND FIFTEENTH MINUTE OF RECOVERY HEART RATES (BEATS PER MINUTE)

Subject Number	Control		Drug		Placebo	
	Rest	Recovery	Rest	Recovery	Rest	Recovery
GROUP A						
1	68	107	67	118	62	96
2	55	70	55	92	51	86
3	55	85	60	105	59	102
4	48	90	65	100	50	88
GROUP B						
5	74	113	71	117	75	105
6	63	97	58	103	61	92
7	61	107	62	123	61	115
8	49	107	51	96	54	90
GROUP C						
9	60	92	57	102	55	90
10	55	93	65	111	58	92
11	65	90	57	92	55	95
12	61	101	65	110	70	92
MEAN	59.5	96.0	61.1	105.8	59.3	95.3
	77.5		83.4		77.3	

TABLE 71

RESTING AND FIFTEENTH MINUTE OF RECOVERY SYSTOLIC BLOOD PRESSURES (MM. HG.)

Subject Number	Control		Drug		Placebo	
	Rest	Recovery	Rest	Recovery	Rest	Recovery
GROUP A						
1	130	120	120	130	120	110
2	130	110	130	110	120	110
3	120	110	120	120	110	110
4	110	110	110	110	120	110
GROUP B						
5	120	120	120	120	130	110
6	120	120	110	110	120	130
7	110	120	120	120	130	120
8	130	120	130	120	120	120
GROUP C						
9	110	120	130	130	120	120
10	110	110	110	120	130	120
11	120	120	130	130	130	120
12	110	110	120	120	110	110
MEAN	118.3	115.8	120.8	120.0	121.7	115.8
	117.1		120.4		118.8	

TABLE 72

RESTING AND FIFTEENTH MINUTE OF RECOVERY DIASTOLIC BLOOD PRESSURES (MM. HG)

Subject Number	Control		Drug		Placebo	
	Rest	Recovery	Rest	Recovery	Rest	Recovery
GROUP A						
1	60	50	60	60	50	50
2	50	50	50	50	40	40
3	50	50	50	50	50	50
4	60	60	50	50	50	50
GROUP B						
5	60	60	60	60	60	60
6	60	60	50	50	60	60
7	60	60	60	60	70	50
8	60	60	60	50	60	60
GROUP C						
9	60	60	60	60	60	50
10	60	50	50	50	60	50
11	50	50	50	40	60	60
12	60	60	60	60	60	60
MEAN	57.5	55.8	55.0	53.3	56.7	53.3
	56.7		54.7		55.0	

TABLE 73

RESTING AND FIFTEENTH MINUTE OF RECOVERY OXYGEN UPTAKES (ML./KG./MIN.)

Subject Number	Control		Drug		Placebo	
	Rest	Recovery	Rest	Recovery	Rest	Recovery
GROUP A						
1	4.54	5.92	5.93	5.94	4.19	6.03
2	4.66	5.43	4.38	6.30	4.90	3.77
3	5.14	3.40	2.63	7.23	2.22	4.73
4	4.49	4.33	6.54	5.46	4.50	3.88
GROUP B						
5	4.01	5.50	4.86	8.55	4.17	6.80
6	2.22	3.39	2.26	5.00	2.18	4.40
7	4.07	6.85	3.35	5.69	5.09	6.47
8	5.17	7.05	4.88	5.14	5.13	5.45
GROUP C						
9	3.70	5.67	4.72	5.22	8.70	7.58
10	6.02	6.96	6.12	7.19	5.64	5.58
11	3.75	3.80	3.80	4.83	4.50	5.36
12	4.64	4.87	3.45	6.36	2.91	4.91
MEAN	4.37	5.26	4.41	6.08	4.51	5.41
	4.82		5.24		4.96	

TABLE 74

URINE SAMPLES

Subject Number	Volume Produced (Milliliters)	pH
1	80	5.8
2	50	6.0
3	154	6.2
4	54	6.4
5	110	6.7
6	70	6.1
7	86	5.9
8	50	7.0
9	124	6.0
10	92	6.2
11	230	6.0
12	82	6.0

TABLE 75

PRELIMINARY TESTING SESSION

Subject Number	Work Load (Kilopond)	Heart Rate (Beats per Minute)	Pedal Revolutions (Revs. of 4th-3rd Minutes)
1	1.0 2.0 3.0	110 132 173	68 71 69
2	1.0 2.0 3.0 3.5 4.0	88 115 138 150 161	60 58 45 60 56
3	1.0 2.0 2.5 3.0	110 132 150 161	66 67 68 67
4	1.0 2.0 2.5 3.0	85 125 155 167	69 72 71 74
5	1.0 2.0 3.0	82 110 141	60 65 67
6	1.0 2.0 3.0	100 136 173	60 67 66
7	1.0 2.0 3.0	98 125 141	57 57 59
8	1.0 2.0 3.0	107 125 155	57 67 68
9	1.0 2.0 3.0 3.5 4.0	108 125 145 158 167	58 59 60 65 65
10	1.0 2.0 2.5 3.0 3.5 4.0	94 115 143 153 150 167	59 62 67 63 65 64
11	1.0 1.5 2.0 2.5 3.0 3.5	100 106 122 125 132 150	58 56 54 53 57 53
12	1.0 2.0 3.0	90 122 161	62 64 64

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